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BULLETIN

OF THE

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VOL. 44

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Errata

Page 152, line 8, for *sandwicense* read *sandwicensis*.
Page 190, line 1, for 4 read 7.
Page 323, line 14 from bottom, for *megaspermum* read *megasperma*.
Page 440, line 9, for *plebeia* read *plebeja*.
Page 442, line 2, for *plebeia* read *plebeja*.
Page 452, line 14 from bottom, for *Brunnonianum* read *Brunnoniana*.
Page 525, line 1, for **Lejunea** read **Lejeunea**.

Vol. 44 No. 1

BULLETIN

OF THE

TORREY BOTANICAL CLUB

JANUARY, 1917.

Studies of West Indian plants—IX

NATHANIEL LORD BRITTON

52. CLEOME PROCUMBENS JACQ. AND ITS RELATIVES

The small, simple-leaved Cleomes of the West Indies, form an interesting and peculiar group of the genus, very different in habit and aspect from the large, typical, compound-leaved ones. Seven species appear to be represented.

Annuals or biennials.
  Pedicels filiform.
    Leaves linear-oblong; pod subterete. 1. *C. Sloanei.*
    Leaves filiform; pod compressed. 2. *C. guianensis.*
  Pedicels very short; leaves very narrowly linear. 3. *C. stenophylla.*
Perennials with woody roots.
  Pod acute or acuminate; leaves linear to oblong, acute or acuminate.
    Leaves acuminate; pedicels half as long as the pods. 4. *C. procumbens.*
    Leaves acute; pedicels as long as the pods or longer.
      Petals about 4 mm. long; leaves oblong to oblong-lanceolate. 5. *C. Wrightii.*
      Petals 8–10 mm. long; leaves narrowly linear. 6. *C. macrorhiza.*
  Pod obtuse; leaves ovate or elliptic, obtuse or rounded. 7. *C. obtusa.*

1. CLEOME SLOANEI Urban, Symb. Ant. 5: 347. 1907

Grassy and sandy places, at low elevations, southern side of Jamaica.

This species is referred by Fawcett and Rendle, as previously by other authors, to *C. procumbens* Jacq., which is, apparently, confined to Hispaniola.

[The BULLETIN for December (43: 601–676) was issued January 10, 1917.]

2. CLEOME GUIANENSIS Aubl. Pl. Guian. 2: 675. 1775

Sandy pine lands, Pinar del Rio, Cuba; northern South America.

3. CLEOME STENOPHYLLA Klotzsch; Urban, Symb. Ant. 4: 251. 1905

Plains at low elevations, southern and southwestern Porto Rico; St. Bart's; Bonaire; hillsides, Curaçao; Guiana.

4. CLEOME PROCUMBENS Jacq. Stirp. Am. 189. *pl. 120.* 1763

Hispaniola. Erroneously recorded from Cuba, and, apparently also erroneously referred to Jamaica, as Jacquin's figure of the type would seem to represent a well-marked species, not collected since its original discovery.

5. CLEOME WRIGHTII Urban, Symb. Ant. 5: 346. 1907

Sandy soil, Pinar del Rio and Isle of Pines, Cuba.

6. CLEOME MACRORHIZA Wright; Sauvalle, Anales Acad. Habana 5: 199. 1868

Pine-lands, Pinar del Rio, Cuba.

7. **Cleome obtusa** sp. nov.

Perennial by a slender woody root, glabrous; stems numerous, prostrate, simple or few-branched, slender, 5–15 cm. long. Leaves ovate or elliptic, 4–6 mm. long, rounded or obtuse at the apex, rounded at the base, the midvein prominent, the lateral venation obscure, the petioles 1–2 mm. long; peduncles slender or filiform, 4–8 mm. long; sepals obtuse, 2–2.5 mm. long; petals yellow, oblong or oblong-obovate, obtuse or acutish, 3–4 mm. long; stamens about two-thirds as long as the petals; filaments filiform; style about 1 mm. long; capsule elliptic, elliptic-obovate or oblong, compressed, 3–6 mm. long, 2–2.5 mm. wide, obtuse at the apex, somewhat narrowed at the base, few–several-seeded.

Dry and rocky soil in palm-barrens and savannas, Camaguey and Santa Clara, and in sand on Cayo Guayaba, Cuba. Type from savannas near Camaguey (*Britton & Cowell 13165*). Hitherto included in *C. Wrightii* Urban.

53. CHAMAECRISTA MOENCH IN THE WEST INDIES

Type species: *Chamaecrista nictitans* (L.) Moench.

A. Sepals rigid, scarious, many-nerved (*Diphyllae*). 1. *C. diphylla*.
B. Sepals membranous, scarcely nerved.
a. Prostrate herbs, the flowers on filiform peduncles.
Leaflets only 1 pair, obovate; stipules cordate (*Rotundifoliae*). 2. *C. rotundifolia*.
Leaflets 3–7 pairs, oblong to obovate; stipules lanceolate (*Pilosae*).
Stems pilose. 3. *C. pilosa*.
Stems appressed-pubescent. 4. *C. serpens*.
b. Erect, ascending or rarely prostrate herbs or shrubs.
1. Midvein of the leaflet central or excentric, not marginal.
* Shrubs, with coriaceous or subcoriaceous leaves.
† Leaflets many, 20–50 pairs, linear; stipules large; stem flexuous (*Flexuosae*). 5. *C. flexuosa*.
†† Leaflets fewer, 2–12 pairs, oblong or obovate; stipules small; stem not flexuous (*Lineatae*).
‡ Foliage densely pubescent. 6. *C. grammica*.
‡‡ Foliage glabrous or puberulent.
§ Leaflets dull.
Leaflets obovate or oblanceolate.
Leaflets 2 or 3 pairs, 5 mm. long or less. 7. *C. obcordata*.
Leaflets 3–11 pairs, 7–15 mm. long.
Gland sessile. 8. *C. lineata*.
Gland stalked. 9. *C. granulata*.
Leaflets oblong.
Leaflets acute, cuspidate. 10. *C. pinetorum*.
Leaflets rounded and mucronulate at apex. 11. *C. jamaicensis*.
§§ Leaflets shining.
Leaflets oblong, or the upper obovate, 1.5 cm. long or less, strongly callous-margined.
Leaflets glabrous; gland large, nearly sessile. 12. *C. portoricensis*.
Leaflets ciliate; gland small, stalked. 13. *C. Tuerckheimii*.
Leaflets elliptic to ovate to obovate, 1.5–3 cm. long, not callous-margined.
Leaflets elliptic, acute. 14 *C. caribaea*.
Leaflets ovate to obovate, obtuse, retuse, or mucronate.
Leaflets 1–3 pairs, obovate, mostly retuse. 15. *C. inaguensis*.

Leaflets 4–9 pairs, ovate to ovate-oblong, mostly obtuse. 16. *C. lucayana.*

** Herbs or shrubs, with membranous leaves (*Glandulosae*).

† Flowers large, 2–4 cm. broad.

Leaflets villous or pubescent beneath.

Glands elongated, petiolar and also often between the leaflets; midvein of leaflets nearly central, the lateral veins many. 17. *C. glandulosa.*

Glands short, sessile, petiolar only; midvein of leaflets excentric, the lateral veins few. 18. *C. Dussii.*

Leaflets glabrous beneath.

Leaflets oblong to linear; gland stipitate. 19. *C. Swartzii.*

Leaflets obovate or oblong; gland sessile or stout-stipitate. 20. *C. polyadena.*

†† Flowers small, seldom over 1 cm. broad.

‡ Petiolar glands sessile, or very short-stalked.

Prostrate; leaflets 4–6 pairs. 21. *C. pygmaea.*

Erect or ascending; leaflets 8 pairs or more.

Plant densely hirsute all over. 22. *C. patellaria.*

Plants glabrate or more or less villous.

Pod black-banded and black-margined. 23. *C. fasciata.*

Pod not black-banded.

Leaflets 10–15 mm. long, the midvein little excentric. 24. *C. aeschinomene.*

Leaflets 5–8 mm. long, the midvein very excentric.

Petals 6 mm. long; plant sparingly short-pubescent. 25. *C. savannarum.*

Petals 3 mm. long; plant villous. 26. *C. micrantha.*

‡‡ Petiolar glands distinctly stalked.

Pod 3.5–4 mm. broad; pubescence widely spreading. 27. *C. riparia.*

Pod 3 mm. broad or less.

Petiolar glands often 2; leaflets oblong; plant glabrous, or pubescent only above. 28. *C. mirabilis.*

Petiolar gland 1; leaflets linear or linear-oblong; plant pubescent or villous. 29. *C. Chamaecrista.*

2. Midvein of the leaflet approximate to its upper margin (*Strigillosae*).

Petiolar gland small, subsessile.

Leaves sparingly pubescent. 30. *C. strigillosa.*

Leaves densely pilose. 31. *C. adenosperma.*

Petiolar gland stalked.
Pod glabrous or nearly so. 32. *C. pedicellaris.*
Pod short-pilose. 33. *C. Buchii.*

1. CHAMAECRISTA DIPHYLLA (L.) Greene, Pittonia 4: 28. 1899

Cassia diphylla L. Sp. Pl. 376. 1753.

TYPE LOCALITY: "In India."

DISTRIBUTION: Provinces of Santa Clara, Pinar del Rio and on Isle of Pines, Cuba; Hispaniola; Porto Rico; recorded by Grisebach from St. Kitts and St. Vincent; continental tropical America.

2. CHAMAECRISTA ROTUNDIFOLIA (Pers.) Greene, Pittonia 4: 31. 1899

Cassia rotundifolia Pers. Syn. 1: 456. 1805.
Cassia bifoliata DC.; Collad. Cass. 120. 1816.

TYPE LOCALITY: South America.

DISTRIBUTION: Provinces of Santa Clara and Pinar del Rio and on Isle of Pines, Cuba; Jamaica; continental tropical America.

ILLUSTRATION: Collad. Cass. *pl. 9.*

3. CHAMAECRISTA PILOSA (L.) Greene, Pittonia 4: 28. 1899

Cassia pilosa L. Syst. Ed. 10, 1017. 1759.
Cassia Milleri Collad. Cass. 132. 1816.

TYPE LOCALITY: Jamaica (Sp. Pl. Ed. 2, 540).

DISTRIBUTION: Province of Pinar del Rio and Isle of Pines, Cuba; Jamaica; northern South America.

4. CHAMAECRISTA SERPENS (L.) Greene, Pittonia 4: 29. 1899.

Cassia serpens L. Syst. Ed. 10, 1018. 1759.

TYPE LOCALITY: Jamaica (Sp. Pl. Ed. 2, 541).

DISTRIBUTION: Provinces of Havana and Pinar del Rio, Cuba; Jamaica; northern South America.

5. CHAMAECRISTA FLEXUOSA (L.) Greene, Pittonia 4: 27. 1899

Cassia flexuosa L. Sp. Pl. 379. 1753.
Chamaecrista amplistipulata Rose, Contr. Nat. Herb. 12: 267. 1909.

TYPE LOCALITY: Brazil.

DISTRIBUTION: Pinar del Rio and Isle of Pines, Cuba; continental tropical America.

ILLUSTRATION: Breyn, *pl. 23*.

6. CHAMAECRISTA GRAMMICA (Spreng.) Pollard, Field Col. Mus. Bot. **2**: 47. 1900

Cassia grammica Spreng. Neue Entd. **3**: 55. 1822.

Cassia lineata brachyloba Griseb. Mem. Am. Acad. II. **8**: 179. 1860.

TYPE LOCALITY: Maritime regions, Cuba and Hispaniola.

DISTRIBUTION: Cuba (according to Sprengel) and collected by Wright in Oriente; Hispaniola; Porto Rico; Little St. James Island, St. Jan.

The plant of southern Florida, referred to this species by Chapman and by Small, is distinct, according to the studies of Dr. Pennell.

7. **Chamaecrista obcordata** (Sw.).

Cassia obcordata Sw.; Wikstr. Vetensk. Acad. Handl. **1825**: 429. 1826.

TYPE LOCALITY: St. Bart's.

DISTRIBUTION: St. Bart's; I refer, with doubt, Dr. Boldinghs' No. 5288B from St. Martin to this species, which he recorded as *Cassia polyadena* DC. (Fl. Nederl. West Ind. 211); the St. Martin plant is more nearly related to *C. lineata* than to *C. polyadena*. Bentham indicates the same affinity for the plant of St. Bart's (Trans. Linn. Soc. **27**: 572). No modern collections have been made on St. Bart's; it lies close to St. Martin.

8. CHAMAECRISTA LINEATA (Sw.) Greene, Pittonia **4**: 31. 1899

Cassia lineata Sw. Prodr. 66. 1788.

Cassia cuneata Griseb. Cat. Pl. Cub. 80. 1866. Not *C. cuneata* DC.

TYPE LOCALITY: Jamaica.

DISTRIBUTION: Jamaica; Cuban provinces of Oriente, Camaguey and Santa Clara, and Isle of Pines; Hispaniola; Bahamas. Specimens from the south coast of Santa Clara, Cuba, have puberulent foliage.

9. CHAMAECRISTA GRANULATA (Urban) Britton, Ann. Missouri Bot. Gard. **2**: 41. 1915

Cassia portoricensis granulata Urban, Symb. Ant. **1**: 318. 1899.

Chamaecrista portoricensis granulata Cook & Collins, Contr. Nat. Herb. **8**: 113. 1903.

TYPE LOCALITY: Near Salinas de Cabo Rojo, Porto Rico.

DISTRIBUTION: Southwestern Porto Rico; Mona.

10. **Chamaecrista pinetorum** sp. nov.

Shrubby, 4 dm. high, or higher, the branches slender, densely appressed-pubescent with brownish hairs. Stipules linear-lanceolate, striate, long-acuminate, 4–6 mm. long; leaves 3–5 cm. long, the rachis appressed-pubescent; leaflets 9 pairs or fewer, subcoriaceous, linear to linear-oblong, 10–15 mm. long, 2–4 mm. wide, glabrous on both sides, dull, acute and cuspidate at the apex, obliquely rounded at the base, closely pinnately veined, the prominent midvein nearly central, the petiolar gland slender-stalked; peduncles filiform, appressed-pubescent, 2-bracted, about 3 cm. long; sepals lanceolate, acuminate, 10–12 mm. long; petals obovate, somewhat shorter than the sepals or as long; ovary appressed-pubescent.

Pine woods, near Constanza, Santo Domingo, at 1,200 m. alt. (*Tuerckheim 2887*).

11. CHAMAECRISTA JAMAICENSIS Britton, Bull. Torrey Club **42**: 515. 1915

TYPE LOCALITY: South slope of Long Mountain, Jamaica.

DISTRIBUTION: Southern side of Jamaica.

12. CHAMAECRISTA PORTORICENSIS (Urban) Cook & Collins, Contr. Nat. Herb. **8**: 113. 1903

Cassia portoricensis Urban, Symb. Ant. **1**: 317. 1899.

Cassia portoricensis callosa Urban, Symb. Ant. **1**: 317. 1899.

Chamaecrista portoricensis callosa Cook & Collins, Contr. Nat. Herb. **8**: 113. 1903.

TYPE LOCALITY: Near Guayanilla, Porto Rico.

DISTRIBUTION: Southern and western Porto Rico.

13. **Chamaecrista Tuerckheimii** sp. nov.

Shrubby, with a deep woody root; stems slender, villous-pubescent, 8–10 cm. long. Stipules obliquely ovate-lanceolate, acuminate, striate, 2–3 mm. long; leaves 2–2.5 cm. long, the rachis villous-pubescent; leaflets 6 or 7 pairs, linear-oblong, to oblong-oblanceolate, 6–8 mm. long, about 2 mm. wide, ciliate, shining, rounded or subtruncate and mucronulate at the apex, obliquely rounded at the base, pinnately veined with the prominent midvein somewhat excentric, the petiolar gland short-stalked; peduncles slender, villous, about 2 cm. long; sepals lanceolate, acuminate, villous, 7–8 mm. long; petals obovate, about twice as long as the sepals; legume linear, narrowed at both ends, nearly glabrous, 1.8 cm. long.

Near Maniel de Ocoa, Santo Domingo, in fields, 300 m. alt. (*Tuerckheim 3680*).

14. **Chamaecrista caribaea** (Northrop)

Cassia caribaea Northrop, Mem. Torrey Club **12**: 39. 1902.

TYPE LOCALITY: Fresh Creek, Andros, Bahamas.

DISTRIBUTION: Andros, New Providence and Cat Island, Bahamas.

ILLUSTRATION: Northrop, *loc. cit. pl. 6.*

15. **Chamaecrista inaguensis** comb. nov.

Cassia inaguensis Britton, Bull. N. Y. Bot. Gard. 3: 443. 1905.

TYPE LOCALITY: Inagua, Bahamas.

DISTRIBUTION: Inagua, South Caicos, Grand Turk, and Ambergris Cay, Bahamas.

16. **Chamaecrista lucayana** comb. nov.

Cassia lucayana Britton, Bull. N. Y. Bot. Gard. 4: 138. 1906.

TYPE LOCALITY: Cay north of Wide Opening, Exuma Chain, Bahamas.

DISTRIBUTION: Great Bahama, Cat Island, Conception, Rum Cay, and Exuma Chain, Bahamas.

17. CHAMAECRISTA GLANDULOSA (L.) Greene, Pittonia 4: 28. 1899

Cassia glandulosa L. Syst. Ed. 10, 1017. 1759.

Cassia virgata Sw. Prodr. 66. 1788.

?*Cassia stricta* Schrank, Hort. Monac. **1**: *pl. 34*. 1819.
Chamaecrista virgata Greene, Pittonia **4**: 31. 1899.

TYPE LOCALITY: Jamaica.

DISTRIBUTION: Jamaica.

ILLUSTRATIONS: Bot. Mag. *pl. 3435;* Schrank, *loc. cit.*

Linnaeus included, in his citations of synonyms of this species, several others, but his description of it, together with his having received a Jamaica specimen from the collection of Patrick Browne, prior to his publication, as I am informed by Dr. B. Daydon Jackson, Secretary of the Linnaean Society of London, show that the name is to be restricted to the Jamaica plant. Subsequent authors have confused it with species from other islands and from continental tropical America. The identity of *Cassia virgata* Sw. was established for me by Mr. William Fawcett at the British Museum of Natural History. *Cassia stricta* Schrank, from the illustration and the Jamaica habitat, appears referable here, but Schrank's description of the plant is not altogether conclusive; he says the root is annual.

18. **Chamaecrista Dussii** sp. nov.

Perennial, villous-pubescent, erect, simple, 5–9 dm. high, somewhat woody. Stipules narrowly lanceolate, strongly striate, 10–12 mm. long; leaves 5–7 cm. long; petiolar gland close to the lowest leaflets, scutelliform, sessile, slightly concave, nearly 1 mm. in diameter; leaflets about 17 pairs, linear, pubescent on both sides, 10–18 mm. long, 2–3 mm. wide, obtuse, mucronate, inequilateral, the midvein excentric, the lateral veins few and distant; peduncles 4–6 mm. long; sepals lanceolate, acuminate, pubescent, about 7 mm. long; petals obovate, 8–10 mm. long; pod linear, slightly curved, villous-pubescent, obliquely short-tipped, 3 cm. long, 5 mm. wide.

Guadeloupe and Martinique. Type from Trou-Vaillant, Parnasse, Martinique (*Père Duss 1121*).

19. **Chamaecrista Swartzii** (Wickstr.)

Cassia Swartzii Wikstr. Vetensk. Acad. Handl. **1825**: 430. 1826.
Chamaecrista complexa Pollard, Field Col. Mus. Bot. **2**: 47. 1900.

TYPE LOCALITY: St. Bart's.

DISTRIBUTION: Porto Rico; Vieques; Culebra; St. Thomas; St. Jan; Tortola; St. Croix; Saba; St. Bart's; St. Kitt's; Dominica; Guadeloupe; Grenada.

The species has been much confused with the Jamaican *C. glandulosa.*

20. **Chamaecrista polyadena** (DC.)

Cassia polyadena DC. Mém. Soc. Hist. Nat. Gen. **2**: 132. 1824.

TYPE LOCALITY: Guadeloupe.

DISTRIBUTION: Guadaloupe; Dominica; Martinique; Barbadoes.

My identification of this species is based on my examination of the type, some years ago, in the Candollean herbarium at Geneva, Switzerland. Notwithstanding the usually sessile petiolar gland and the relatively broader leaflets, I am not confident that this species is distinct from the preceding one.

21. **Chamaecrista pygmaea** (DC.)

Cassia pygmaea DC. Mém. Soc. Hist. Nat. Gen. **2**: 131. 1824.

TYPE LOCALITY: Santo Domingo.

DISTRIBUTION: Hispaniola.

Referred by Bentham to *Cassia procumbens* L., which is a synonym of *C. nictitans* L. of continental North America, as previously indicated by me (Bull. Torrey Club **43**: 463).

22. CHAMAECRISTA PATELLARIA (DC.) Greene, Pittonia **4**: 32. 1899

Cassia patellaria DC.; Collad. Cass. 125. 1816.

TYPE LOCALITY: Cayenne.

DISTRIBUTION: Jamaica; all provinces of Cuba and on the Isle of Pines; continental tropical America.

ILLUSTRATION: Collad. Cass. *pl. 16.*

23. CHAMAECRISTA FASCIATA Britton, Bull. Torrey Club **37**: 352. 1910

TYPE LOCALITY: Between Bath and Cuna-Cuna Gap, Jamaica.

DISTRIBUTION: Jamaica; Cuban provinces of Oriente, Camaguey, Santa Clara and Havana.

24. CHAMAECRISTA AESCHINOMENE (DC.) Greene, Pittonia **4**: 32. 1899

Cassia aeschinomene DC.; Collad. Cass. 127. 1816.

Chamaecrista Millspaughii Pollard, Field Col. Mus. Bot. **2**: 47. 1900.

Cassia mimosoides aeschynomene Benth. Trans. Linn. Soc. **27**: 579. 1871.

TYPE LOCALITY: Santo Domingo.

DISTRIBUTION: Jamaica; all provinces of Cuba; Hispaniola; Porto Rico.

ILLUSTRATION: Collad. Cass. *pl. 17*.

25. CHAMAECRISTA SAVANNARUM Britton, Bull. Torrey Club **43**: 463. 1916

TYPE LOCALITY: Near Siguanea, Isle of Pines, Cuba.

DISTRIBUTION: Savannas and pine-lands, Pinar del Rio and Isle of Pines, Cuba.

26. CHAMAECRISTA MICRANTHA Britton, Bull. Torrey Club **43**: 463. 1916

TYPE LOCALITY: Near San Pedro, Isle of Pines, Cuba.

DISTRIBUTION: Pine-lands and savannas, Pinar del Rio and Isle of Pines, Cuba. Referred by Grisebach to *Cassia pygmaea* DC.

27. **Chamaecrista riparia** (HBK.)

Cassia riparia HBK. Nov. Gen. **6**: 369. 1824.

TYPE LOCALITY: Banks of the Magdelena River near Mompox.

DISTRIBUTION: Jamaica; province of Havana, Cuba; Grand Cayman; Andros, New Providence and Eleuthera, Bahamas; northern South America and recorded from Central America.

The plant of the Bahamas was referred by me with some doubt (Bull. N. Y. Bot. Gard. **3**: 443) to *Cassia aspera* Muhl., which it closely resembles, except in the petiolar gland. Cuban and Jamaican specimens differ from the Bahaman in having the gland somewhat longer-stalked.

I have not been able to study an authentic specimen of *C. riparia*. Bentham's record of it as West Indian was based upon a plant collected in Cuba by Liebmann, preserved in the Kew herbarium.

28. CHAMAECRISTA MIRABILIS Pollard, Proc. Biol. Soc. Wash. **15**: 19. 1902

Cassia mirabilis Urban, Symb. Ant. **4**: 276. 1905.

TYPE LOCALITY: Rio Piedras, Porto Rico.

DISTRIBUTION: Northern coastal plain of Porto Rico.

29. **Chamaecrista Chamaecrista** (L.)

Cassia Chamaecrista L. Sp. Pl. 379. 1753.
Cassia diffusa DC. Mém. Soc. Hist. Nat. Gen. **2**: 130. 1824.
Cassia smaragdina Macf. Fl. Jam. **1**: 347. 1837.
Chamaecrista diffusa Britton, Ann. Missouri Bot. Gard. **2**: 41. 1915.

TYPE LOCALITY: Curaçao.

DISTRIBUTION: Bahamas; Jamaica; Cuba; ? Hispaniola; Porto Rico; St. Jan; St. Croix; St. Kitts; Guadeloupe; Grenada; Curaçao; Margarita.

ILLUSTRATIONS: Breyn, *pl. 24;* Schrank, Hort. Monac. *pl. 33.*

The species has been much confused with the annual *C. nictitans* of eastern continental North America.

The recognition of the plant of Curaçao as typical *Cassia Chamaecrista* brings *C. diffusa* into its synonymy.

30. **Chamaecrista strigillosa** (Benth.)

Cassia strigillosa Benth. Trans. Linn. Soc. **27**: 581. 1871.

TYPE LOCALITY: Cuba.

DISTRIBUTION: Province of Oriente, Cuba; Santo Domingo (according to Bentham). Referred by Grisebach to *Cassia serpens* L.

31. **Chamaecrista adenosperma** (Urban)

Cassia adenosperma Urban, Symb. Ant. **5**: 362. 1908.

TYPE LOCALITY: Sierra del Palo Quemado, Santo Domingo.

DISTRIBUTION: Known only from the type locality, and, to me, only from the description.

32. **Chamaecrista pedicellaris** (DC.)

Cassia pedicellaris DC. Prodr. **2**: 504. 1825.

TYPE LOCALITY: Santo Domingo.

DISTRIBUTION: Hispaniola.

33. **Chamaecrista Buchii** (Urban)

Cassia Buchii Urban, Symb. Ant. **5**: 361. 1908.

TYPE LOCALITY: Near Gonaives, Haiti.

DISTRIBUTION: Known only from the type locality and, to me, only from the description.

54. THE GENUS LEUCOCROTON GRISEB.

A Cuban genus, of which four species have been described. *L. Wrightii* Griseb. is the type species.

- *A*. Leaves pinnately veined.
  - Leaves chartaceous.
    - Pistillate inflorescence 1-flowered at the summit; staminate flowers racemose. 1. *L. Wrightii.*
    - Pistillate flowers racemose, the staminate glomerate-spicate. 2. *L. flavicans.*
  - Leaves coriaceous, linear-oblong or linear.
    - Leaves densely whitish-scurfy beneath.
      - Leaves strongly revolute-margined, not reticulate-veined beneath, coarsely reticulate-veined above. 3. *L. revolutus.*
      - Leaves slightly revolute-margined, strongly reticulate-veined beneath, finely reticulate-veined above. 4. *L. saxicola.*
    - Leaves glabrous on both sides.
      - Leaves mostly rounded and mucronulate at the apex, dull, 6–10 mm. wide. 5. *L. angustifolius.*
      - Leaves emarginate, shining, 3–5 mm. wide. 6. *L. linearifolius.*
- *B*. Leaves palmately 5-veined. 7. *L. virens.*

1. LEUCOCROTON WRIGHTII Griseb. Abh. Kön. Gesell. Wiss. Götting. 9: 21. 1860

Woodlands and banks of streams, Oriente; Pinar del Rio.

2. LEUCOCROTON FLAVICANS Muell. Arg. in DC. Prodr. 15^2: 757. 1866

L. flavicans latifolius Muell. Arg. *loc. cit.* 1866.
L. flavicans angustifolius Muell. Arg. *loc. cit.* 1866.

Serpentine hillsides, Matanzas, Havana. The locality of C. Wright's no. 1994 is not recorded.

3. LEUCOCROTON REVOLUTUS Wright; Sauvalle, Anales Acad. Habana 7: 154. 1870

Known only from the type locality between La Mulata and La Palme, Pinar del Rio.

4. **Leucocroton saxicola** sp. nov.

A shrub, 1–3.3 m. high, much branched, the twigs short and stout. Leaves coriaceous or subcoriaceous, narrowly oblong or oblanceolate, 3–11 cm. long, 2 cm. wide or less, rounded or emarginate and apiculate at the apex, narrowed at the base, finely reticulate-veined, glabrous, and with impressed midvein above, strongly reticulate-veined, minutely scurfy and with prominent midvein beneath, the petioles 3–6 mm. long; staminate flowers racemose-spicate in the upper axils, the inflorescence 2–3 cm. long; bracts lanceolate, acute, about 1.5 mm. long; pedicels 1–2 mm. long; buds subglobose, lepidote, 1 mm. in diameter.

Rocky banks and hillsides, mountains of northern Oriente. Type collected at Arroyo del Medio, above the falls, 450–550 m. alt. (*Shafer 3466*).

Similar to *L. revolutus*, but the venation of the leaves is quite different. In *L. revolutus* only the pistillate inflorescence is known; in *L. saxicola* only the staminate.

5. **Leucocroton angustifolius** sp. nov.

A much-branched, spreading shrub, about 6 dm. high, the twigs bearing distant leaf-scars. Leaves scattered, coriaceous, glabrous, linear or linear-oblong, 5–10 cm. long, 13 mm. wide or less, revolute-margined, rounded and mucronulate or emarginate at the apex, narrowed at the base, the midvein impressed above, prominent beneath, the primary lateral veins numerous, diverging at nearly right angles from the midvein, both surfaces reticulate-veined, the petioles 4–6 mm. long; pistillate flowers solitary at the ends of clustered, terminal, slender, scaly, bracted peduncles 2–3 cm. long; bracts lanceolate, numerous, acute, ascending, 1.5 mm. long; calyx-segments lanceolate, similar to the bracts; ovary depressed-globose, obtusely 3-lobed, lepidote; styles stout, recurved.

Rio Guayabo, above the falls, Oriente, 450–550 m. alt. (*Shafer 3626*).

6. **Leucocroton** (?) **linearifolius** sp. nov.

A much-branched shrub about 6 dm. high, the twigs short, stiff, covered by leaf-scars. Leaves densely clustered at the ends of the twigs, coriaceous, glabrous, linear, 3–6 cm. long, 3–5 mm. wide, shining on both sides, emarginate at the apex, gradually narrowed to the base, short-petioled, the midvein impressed above, prominent beneath, the lateral veins very numerous and close together, prominent on both surfaces, diverging nearly at right angles to the midvein, simple, or forked; staminate flowers few, in short, solitary slender-peduncled racemes shorter than the leaves, the pedicels filiform, 2 mm. long, the bractlets linear-lanceolate; bud of the staminate flower globose, 1 mm. in diameter.

Rocky bank of river at Camp La Barga, Oriente, 450 m. alt. (*Shafer 4144*).

7. LEUCOCROTON VIRENS Griseb. Nachr. Gesell. Wiss. Götting. 1865: 175

Mountain woodlands, Oriente. The foliage of this species is very different from that of the others.

55. PASSIFLORA IN CUBA

Type species: *Passiflora incarnata* L.

A. Flowers subtended by 3 large foliaceous bracts [GRANADILLA].
Bracts united below the middle; leaves ovate, entire, membranous. 1. *P. maliformis*.
Bracts distinct to the base.
Branches sharply 4-angled; leaves ovate, entire, membranous. 2. *P. quadrangularis*.
Branches not 4-angled.
Leaves entire, subcoriaceous, glabrous. 3. *P. laurifolia*.
Leaves lobed or parted.
Leaves pedately parted, membranous, pubescent, the segments serrate. 4. *P. pedata*.
Leaves obtusely 3-lobed, glabrous, the lobes entire. 5. *P. pallens*.
B. Flowers subtended by small or pectinate-pinnatifid bracts, or bractless.
1. Flower-tube cylindric or cylindric-campanulate; corona not plicate [MURUCUJA].
Leaves entire, ovate to elliptic. 6. *P. cuprea*.
Leaves lobed or subtruncate.
Leaves 2-lobed or subtruncate.
Leaves membranous, not reticulate-veined, deeply 2-lobed, the lobes acute. 7. *P. nipensis*.
Leaves coriaceous, reticulate-veined, the lobes obtuse or rounded, or apex subtruncate. 8. *P. cubensis*.
Leaves 3-lobed at the apex. 9. *P. Shaferi*.
2. Flower-tube short or none; corona longitudinally plicate [PLECTROSTEMMA].
A. Petals none.
Leaves 3-divided, the segments stalked, 3-cleft. 10. *P. Berteriana*.
Leaves lobed or entire. 11. *P pallida*.
B. Petals present.
a. Flowers subtended by pinnatisect bracts.
Leaves membranous, flaccid. 12. *P. foetida*.
Leaves chartaceous.
Plant densely velvety-pubescent. 13. *P. gossypifolia*.
Plants glabrous, usually with some stalked glands. 14. *P. pseudociliata*.
b. Bracts small, not pectinate-pinnatifid.
* Peduncles elongated, 1-flowered, longer than the leaves. 15. *P. penduliflora*.

** Peduncles much shorter than the leaves.
Leaves 2-lobed, mostly broader than long.
Flowers solitary, slender-peduncled, 3–4 cm. broad; fruit 3–5 cm. in diameter. 16. *P. rubra.*
Flowers clustered in the axils, 1.5–2 cm. broad, very short-peduncled, the pedicels slender; fruit about 8 mm. in diameter. 17. *P. sexflora.*
Leaves entire or bluntly 3-lobed, longer than broad.
Leaves oblong or oblong-lanceolate, entire, rounded at the base. 18. *P. multiflora.*
Leaves broadly ovate, obtusely 3-lobed, mostly cordate at the base. 19. *P. holosericea.*
C. Published species not grouped.
Leaves ovate to elliptic, dentate. 20. *P. dasyadenia.*
D. Known only from foliage. Leaves deeply 3-lobed, the lobes dentate. 21. A plant of the Isle of Pines.

1. PASSIFLORA MALIFORMIS L. Sp. Pl. 956. 1753

TYPE LOCALITY: Near Port de Paix, Santo Domingo.

DISTRIBUTION: Oriente, collected by Wright:—Hispaniola to Barbadoes; Jamaica; South America. Perhaps not indigenous in Cuba.

2. PASSIFLORA QUADRANGULARIS L. Syst. Ed. 10, 1248. 1759

TYPE LOCALITY: Jamaica.

DISTRIBUTION: Uncommon at Santiago de las Vegas (*Van Hermann 616*):—Native of Nicaragua; widely cultivated in tropical America, and locally spontaneous.

3. PASSIFLORA LAURIFOLIA L. Sp. Pl. 956. 1753

TYPE LOCALITY: Surinam.

DISTRIBUTION: Thicket, upper valley of the Rio Navas, Oriente (*Shafer 4411*):—native from St. Thomas and St. Jan to Trinidad and South America. Spontaneous after cultivation in Hispaniola and Jamaica.

4. PASSIFLORA PEDATA L. Sp. Pl. 960. 1753

TYPE LOCALITY: Santo Domingo.

DISTRIBUTION: Woods and thickets, Santa Clara, Pinar del Rio:—Hispaniola; northern South America.

5. PASSIFLORA PALLENS Poepp.; Masters in Mart. Fl. Bras. 13[1]: 567. *pl. 128, f. 4.* 1872

TYPE LOCALITY: Cuba.

DISTRIBUTION: Thickets, Havana, Pinar del Rio:—Florida; Venezuela.

Recorded by Grisebach and by Sauvalle as *P. stipulata* Aubl.

6. PASSIFLORA CUPREA L. Sp. Pl. 955. 1753

TYPE LOCALITY: New Providence, Bahamas.

DISTRIBUTION: Near Baracoa, Oriente; cays of northern Camaguey:—Bahamas.

7. **Passiflora nipensis** sp. nov.

Glabrous, glandless, slender, 8 dm. long or longer. Leaves cuneate, 2-lobed to the middle or beyond, 1.5–3 cm. long, rather strongly 3-nerved, the nerves impressed above, prominent beneath, excurrent, the secondary venation sparse and slender, the lobes lanceolate, acute, the slender petioles 2.5–5 mm. long; tendrils filiform, 2–4 cm. long; peduncles solitary or geminate in the axils, 10–14 mm. long; fruit globose, dark blue, about 1.5 cm. in diameter; seeds oblong, transversely ridged, about 3 mm. long.

Open dry situations in pine lands, Sierra Nipe near Woodfred, Oriente, 500–650 m. alt. (*Shafer 3554*).

8. PASSIFLORA CUBENSIS Urban, Symb. Ant. 3: 326. 1902

Passiflora coriacea A. Rich. in Sagra, Hist. Cub. 10: 288. 1845. Not Juss.

TYPE LOCALITY: Cuba.

DISTRIBUTION: Serpentine barrens, savannas and coastal thickets, Oriente, Camaguey, Santa Clara, Havana. Endemic.

Referred by Grisebach to *P. murucuja* L. and to *P. oblongata* Sw. The species is variable in leaf-form.

9. **Passiflora Shaferi** sp. nov.

A glabrous vine, about 2 m. long. Leaves thin, elliptic-obovate, 4–5 cm. long, bluntly and shallowly 3-lobed at the apex, rounded or obtuse at the base, strongly 3-nerved, each nerve extending to a lobe and scarcely, if at all, excurrent, with 2 weaker short basal nerves, both surfaces reticulate-veined, the upper surface somewhat shining, the lower dull, the glandless petioles 4–7 mm. long; peduncles mostly 2 together in the axils, 1–2 cm. long; bractlets subulate, 1.5–2 mm. long; flowers about 3 cm. long, red, the tube cylindric, 1–1.5 cm. long; fruit subglobose, about 1 cm. in diameter.

Between Navas and Camp Buena Vista, Oriente, at 650 m. alt. (*Shafer 4466*).

10. PASSIFLORA BERTERIANA Balb.; DC. Prodr. 3: 325. 1828

TYPE LOCALITY: Santo Domingo.

DISTRIBUTION: Recorded by Grisebach as collected in Cuba by Wright:—Santo Domingo.

11. PASSIFLORA PALLIDA L. Sp. Pl. 955. 1753

Passiflora minima L. Sp. Pl. 959. 1753.
Passiflora suberosa L. Sp. Pl. 958. 1753.
Passiflora hirsuta L. Sp. Pl. 958. 1753.
Passiflora angustifolia Sw. Prodr. 97. 1788.
Passiflora hederacea Cav. Diss. 10: 448. 1790.

TYPE LOCALITY: Santo Domingo.

DISTRIBUTION: Banks, thickets and hillsides, all provinces and Isle of Pines:—Florida; Bermuda; West Indies and tropical continental America. The many races differ in leaf-form and pubescence.

12. PASSIFLORA FOETIDA L. Sp. Pl. 959. 1753

TYPE LOCALITY: Dominica.

DISTRIBUTION: Thickets and roadsides, Oriente, Havana, Pinar del Rio, Isle of Pines:—West Indies; continental tropical America; Old World tropics.

13. PASSIFLORA GOSSYPIFOLIA Desv. in Hamilt. Prodr. Pl. Ind. Occ. 48: 1825

P. foetida gossypifolia Masters in Mart. Fl. Bras. 13[1]: 582. 1872.

TYPE LOCALITY: Not cited, presumably West Indian.

DISTRIBUTION: Dry hillsides, southern Oriente:—continental tropical America.

14. **Passiflora pseudociliata** sp. nov.

? *Passiflora ciliata polyadena* Griseb. Cat. Pl. Cub. 285. 1866.

Herbaceous, glabrous, 2 m. long or less. Leaves membranous, but not flaccid, variously 3-lobed, or sometimes 5-lobed, 2–8 cm. broad, bearing few or many slender-stalked glands, or glandless, the lobes oblong, acute or obtuse, few-toothed or entire, the slender petioles 1–5 cm. long; peduncles solitary in the axils, longer than the petioles, sometimes nearly as long as the leaves; bracts pectinate-pinnatifid; flowers blue, 4–6 cm. broad; petals narrowly oblong, blunt; crown-processes filiform, much shorter than the petals; fruit inflated, bladdery, ellipsoid or subglobose, red, 3–6 cm. long, short-stipitate, longer than the bracts.

Barren hillsides and coastal thickets, Camaguey, Santa Clara, Matanzas, Havana, Pinar del Rio.

Type from rocky soil in savanna near Camaguey (*Britton & Cowell 13155*).

Referred by Grisebach to *P. ciliata* Ait., and by Combs to *P. foetida* L.

Specimens from the Sierra Nipe, Oriente, with large leaves and fruit (*Shafer 3081, 3618*) are doubtfully referred to *P. ciliata* Ait., but they do not show the bracts, which, in *P. ciliata* of Jamaica, are as long as the fruit or longer.

15. PASSIFLORA PENDULIFLORA Bert.; DC. Prodr. **3**: 326. 1828

TYPE LOCALITY: Jamaica.

DISTRIBUTION: Coastal woods and thickets, Oriente, Camaguey:—Jamaica.

16. PASSIFLORA RUBRA L. Sp. Pl. 956. 1753

TYPE LOCALITY: Martinique.

DISTRIBUTION: Banks and thickets at lower and middle elevations, Oriente, Camaguey, Santa Clara, Matanzas, Havana:—West Indies; continental tropical America.

The *Passiflora pubescens* HBK., recorded as Cuban by A. Richard, is, presumably, this species.

17. PASSIFLORA SEXFLORA Juss. Ann. Mus. Paris **6**: 110. *pl. 37, f. 1.* 1805

TYPE LOCALITY: Santo Domingo.

DISTRIBUTION: Thickets and hillsides, Oriente, Santa Clara:—

Florida; Jamaica; Hispaniola; Porto Rico; recorded from St. Kitts; Mexico and Central America.

18. PASSIFLORA MULTIFLORA L. Sp. Pl. 956. 1753

TYPE LOCALITY: Near Port de Paix, Santo Domingo.

DISTRIBUTION: Rocky banks and coastal thickets, Oriente, Camaguey, Santa Clara, Pinar del Rio, Isle of Pines:—Florida, Bahamas; Hispaniola to Tortola; recorded from Costa Rica.

19. PASSIFLORA HOLOSERICEA L. Sp. Pl. 958. 1753

Passiflora reticulata C. Wright; Sauvalle, Anales Acad. Habana **6**: 96. 1869.

TYPE LOCALITY: Vera Cruz [Mexico].

DISTRIBUTION: Rocky hillsides and coastal thickets, Matanzas, Pinar del Rio:—Mexico.

20. PASSIFLORA DASYADENIA Urban, Symb. Ant. 3: 328. 1902

TYPE LOCALITY: Near El Aji [Oriente].

DISTRIBUTION: Type locality and collected also on the Sierra de Anafe, Pinar del Rio (*Wilson & Leon 11534*); flowers of both the Oriente and the Pinar del Rio plant are unknown.

21. PASSIFLORA

A high climbing, sparingly pubescent vine. Petioles slender, 2–4 cm. long, bearing 2 small glands below the middle; leaves subchartaceous, deeply 3-lobed, subtruncate at base, 10 cm. long or less, the oblong lobes 1–3 cm. wide, acute, dentate, loosely reticulate-veined.

Coastal plain, San Juan, Isle of Pines (*Britton & Wilson 15476*).

Passiflora incarnata L. of eastern continental North America is recorded by A. Richard (Sagra, Hist. Cub. **10**: 289) as having been found in Cuba, but I have no other evidence of its occurrence there.

56. RONDELETIA IN CUBA

Type species: *Rondeletia americana* L.

A. Capsule globose to globose-pyriform.
  1. Inflorescence terminal or terminal and axillary.
    ***a.* Twigs strigose.**
      Cymes several–many-flowered; leaves elliptic to ovate-elliptic, 3–8 cm. long. 1. *R. odorata*.

Peduncles 1–3-flowered; leaves oblong, 5–20 mm. long. 2. *R. microphylla.*

b. Twigs glabrous or puberulent.

* Pedicels very slender or filiform.

† Leaves small, 1–2.5 cm. long; peduncles 1- to few-flowered.

Calyx-lobes dilated above.

Leaves ovate, rounded or subcordate at the base; calyx-lobes little dilated. 3. *R. Shaferi.*

Leaves oblong, oval or obovate, narrowed or obtuse at the base; calyx-lobes much dilated.

Wholly glabrous; petioles 1–2 mm. long. 4. *R. peduncularis.*

Petioles ciliate, 4–7 mm. long. 5. *R. pachyphylla.*

Calyx-lobes linear or subulate, not dilated.

Foliage puberulent. 6. *R. pedicellaris.*

Foliage glabrous. 7. *R. alaternoides.*

†† Leaves up to 7 cm. long; inflorescence several- to many-flowered. 8. *R. subglabra.*

** Pedicels stout, short.

† Leaves petioled.

Capsule subglobose or short-pyriform.

Corolla densely silky-pubescent. 9. *R. brachycarpa.*

Corolla glabrous or with a few scattered hairs.

Calyx-teeth deltoid, minute. 10. *R. stellata.*

Calyx-teeth ovate or oblong.

Petioles slender; capsule subglobose. 11. *R. angustata.*

Petioles stout; capsule subpyriform. 12. *R. canellaefolia.*

Capsule oblong, about twice as long as thick; leaves elongated, petioled. 13. *R. calcicola.*

†† Leaves sessile, oblong-oblanceolate; capsule short-pyriform. 14. *R. yamuriensis.*

2. Inflorescence axillary or lateral.

a. Peduncles elongated, often as long as the leaves or longer.

Leaves sessile, cordate, 5–8 cm. long. 15. *R. correifolia.*

Leaves petioled, 3–5 cm. long.

Petioles about 2 mm. long. 16. *R. Lindeniana.*

Petioles 8–12 mm. long.

Stipules triangular, obtuse; leaves obtuse or rounded at the base. 17. *R. nimanimae.*

Stipules linear-subulate, broadened below; leaves rounded at the base. 18. *R. Leoni.*

b. Peduncles short, much shorter than the leaves.

* Leaves membranous to chartaceous; inflorescence mostly few- to several-flowered, rarely 1-flowered.

† Leaves faintly reticulate-veined beneath or not reticulate-veined.
Leaves glabrous, or merely puberulent, the venation obscure. 19. ***R. chamaebuxifolia.***
Leaves densely strigose-pubescent beneath, pinnately veined. 20. ***R. intermixta.***
†† Leaves strongly reticulate-veined beneath.
‡ Leaves ovate to elliptic.
Leaves rounded at the apex.
Calyx-lobes triangular; leaves 4 cm. long or less, the petioles stout. 21. ***R. lomensis.***
Calyx-lobes ovate-oblong; leaves 2 cm. long or less, the petioles slender. 22. ***R. baracoensis.***
Leaves acute or acutish at the apex; inflorescence subcapitate.
Inflorescence subsessile. 23. ***R. rigida.***
Inflorescence manifestly peduncled. 24. ***R. nipensis.***
‡‡ Leaves oblong.
Calyx-lobes linear, linear-lanceolate or ovate, acute or acutish.
Leaves 1 cm. long or less. 25. ***R. Rugelii.***
Leaves 1.5–6 cm. long. 26. ***R. Combsii.***
Calyx-lobes broadly ovate, rounded or obtuse.
Leaves tomentulose beneath. 27. ***R. camarioca.***
Leaves strigose on the veins beneath. 28. ***R. insularis.***
**** Leaves coriaceous, mostly small; peduncles mostly 1-flowered.**
Leaves elliptic to orbicular, obtuse or rounded.
Leaves silvery-puberulent beneath. 29. ***R. savannarum.***
Leaves tomentose beneath.
Leaves elliptic, 1.5–2 cm. long; calyx-lobes linear-lanceolate, acuminate. 30. ***R. venosa.***
Leaves oval or orbicular, 5–15 mm. long; calyx-lobes oblong, obtuse. 31. ***R. hypoleuca.***
Leaves oblong, acute or acutish.
Leaves glabrous, green both sides. 32. ***R. vacciniifolia.***
Leaves white-tomentulose beneath, dark-green and glabrous above. 33. ***R. bicolor.***
B.* Capsule linear-oblong, 2 cm. long; inflorescence terminal.** 34. ***R. tinifolia.
C.* Species not grouped.** 35. ***R. camagueyensis.

1. RONDELETIA ODORATA Jacq. Enum. Pl. Carib. 16. 1760

R. speciosa Lodd. Bot. Cab. 19: *pl. 1893*. 1832.

TYPE LOCALITY: Coastal thickets, Havana [Jacquin, Sel. Stirp. 59].

DISTRIBUTION: Hillsides and thickets at lower and middle elevations, Santa Clara, Matanzas, Havana, Pinar del Rio. Recorded by Richard from Oriente. Recorded from Mexico. Cultivated for ornament.

2. **RONDELETIA MICROPHYLLA** Griseb. Cat. Pl. Cub. 127. 1866

TYPE LOCALITY: Western Cuba.

DISTRIBUTION: River-banks, Pinar del Rio. Endemic.

The leaves are sometimes larger than those of the type specimens, attaining a length of 3 cm.

3. **RONDELETIA SHAFERI** Urban & Britton; Urban, Symb. Ant. 7: 398. 1912

TYPE LOCALITY: Barren savannas near Holguin, Oriente.

DISTRIBUTION: Known only from the type locality.

Dr. Shafer's notes indicate that the plant grows along watercourses.

4. **RONDELETIA PEDUNCULARIS** A. Rich. in Sagra, Hist. Cub. 11: 14. 1850

TYPE LOCALITY: Vuelta de Abajo.

DISTRIBUTION: Rocky banks and beds of streams, Oriente, Pinar del Rio. Endemic.

5. **RONDELETIA PACHYPHYLLA** Krug & Urban; Urban, Symb. Ant. 1: 419. 1899

TYPE LOCALITY: Cuba.

DISTRIBUTION: Rocky stream-beds, mountains of northern Oriente. Endemic.

Recorded by Grisebach as *R. alaternoides* A. Rich. The inflorescence is both terminal and axillary.

6. **RONDELETIA PEDICELLARIS** C. Wright; Sauvalle, Anales Acad. Habana 6: 102, 121. 1869

TYPE LOCALITY: Vicinity of Trinidad.

DISTRIBUTION: Cliffs and rocky hillsides, southern Santa Clara. Endemic.

7. RONDELETIA ALATERNOIDES A. Rich. in Sagra, Hist. Cub. **11**: 13. 1850

TYPE LOCALITY: Mountains near Santiago [Oriente].

DISTRIBUTION: Known only from the type locality.

Urban states (Symb. Ant. **1**: 419) that the inflorescence of this species is terminal, not axillary as first described.

8. RONDELETIA SUBGLABRA Krug & Urban; Urban, Symb. Ant. **1**: 418. 1899

TYPE LOCALITY: Near Santiago, at 1,400 m. elevation [Oriente].

DISTRIBUTION: Mountains of Oriente. Endemic.

9. RONDELETIA BRACHYCARPA (Griseb.) C. Wright; Sauvalle, Anales Acad. Habana **6**: 122. 1869

Ferdinandea brachycarpa Griseb. Mem. Am. Acad. II. **8**: 505. 1862.

TYPE LOCALITY: Thickets near Santa Catalina [Oriente].

DISTRIBUTION: Thickets and hillsides, Oriente, Camaguey, Santa Clara, Havana, Pinar del Rio:—Hispaniola.

Referred by Combs to *R. trifolia* Jacq.

10. RONDELETIA STELLATA (Griseb.) C. Wright; Sauvalle, Anales Acad. Habana. **6**: 122. 1869

Ferdinandea stellata Griseb. Mem. Am. Acad. II. **8**: 505. 1862.

TYPE LOCALITY: Pine-lands near Monte Verde [Oriente].

DISTRIBUTION: Mountains of northern Oriente. Endemic.

11. RONDELETIA ANGUSTATA C. Wright; Sauvalle, Anales Acad. Habana **6**: 122. 1869

Ferdinandea angustata C. Wright; Griseb. Cat. Pl. Cub. 127. 1866.

TYPE LOCALITY: In bogs near Toscano.

DISTRIBUTION: Arroyos and barrens, Santa Clara, Matanzas, Pinar del Rio. Endemic.

12. **Rondeletia canellaefolia** sp. nov.

A glabrous shrub about 2.5 m. high, the twigs rather stout. Leaves coriaceous, elliptic-obovate or elliptic-oblanceolate, opposite or verticellate, 10 cm. long or less, 1.5–3 cm. wide, dark green, shining above, dull beneath, obtuse or acute at the apex, cuneate at the base, the midvein prominent, the lateral veins few, distant, slender, the petioles 5–15 mm. long; inflorescence terminal and in the upper axils, few–several-flowered; peduncles 1.5–5 cm. long; pedicels short and stout; bracts triangular, minute; calyx 3–4 mm. long, its lobes foliaceous, ovate, obtuse, 1–1.5 mm. long; corolla glabrous, about 4 mm. long (immature); capsule pyriform, 1–1.5 cm. long.

Woods and on cliffs, Sierra Nipe, near Woodfred, Oriente, 450–550 m. alt. Type, *Shafer 3297*. In foliage and capsules similar to *R. stellata*, but that has minute calyx-lobes.

13. RONDELETIA CALCICOLA Britton, Bull. Torrey Club **43**: 467. 1916

TYPE LOCALITY: Coe's Camp, Ensenada de Siguanea, Isle of Pines.

DISTRIBUTION: Known only from the type locality.

14. **Rondeletia yamuriensis** sp. nov.

A small tree, about 4 m. high, glabrous throughout. Leaves coriaceous, narrowly oblong-oblanceolate, 6–9 cm. long, 1–2 cm. wide, sessile, acute or obtuse at the apex, narrowed at the base, opposite or verticillate in 3's, the midvein rather prominent, the lateral veins few and slender; inflorescence terminal and also in the uppermost axils; peduncles rather slender, 6 cm. long or less; fruiting pedicels 5–10 mm. long; capsule globose-pyriform, about 1 cm. long.

Between Yamuri Arriba and Bermejal, Oriente (*Shafer 8439*).

15. RONDELETIA CORREIFOLIA Griseb. Cat. Pl. Cub. 129. 1866

TYPE LOCALITY: Western Cuba.

DISTRIBUTION: Pine-lands and savannas, Pinar del Rio and Isle of Pines. Endemic. A virgate shrub, up to 2 m. high, the large white flowers fragrant.

16. RONDELETIA LINDENIANA A. Rich. in Sagra, Hist. Cub. **11**: 13. 1850

TYPE LOCALITY: Mountains near Santiago [Oriente].

DISTRIBUTION: Mountains of Oriente. Endemic. Recorded by Grisebach as *R. buxifolia* Vahl, and, doubtfully, by Sauvalle, as *R. umbellulata* Sw.

17. RONDELETIA NIMANIMAE Krug & Urban; Urban, Symb. Ant. 1: 418. 1899

TYPE LOCALITY: Near Nimanima, at 800 m. alt. [Oriente].
DISTRIBUTION: Known only from the type locality.

18. **Rondeletia Leoni** sp. nov.

A shrub or small tree up to 3 m. high, the slender young twigs, the petioles and the inflorescence appressed-pubescent with short, whitish hairs. Leaves elliptic to obovate, 3–8 cm. long, subcoriaceous, acute, short-acuminate, or some of them obtuse at the apex, narrowed or cuneate at the base, flat, or the margins somewhat revolute when old, densely pubescent with appressed hairs when young, glabrous, or sparingly pubescent on the veins beneath when old, inconspicuously reticulate-veined, the slender petioles 12 mm. long or less; stipules linear-subulate with a broadened base, pubescent, 3–4 mm. long; inflorescence axillary or lateral, 4–6 cm. long, 1–few-flowered, sometimes with a pair of small, leaf-like bracts; pedicels nearly filiform, 1–2 cm. long; bractlets linear-subulate; calyx ovoid-campanulate, densely canescent, its lobes linear or linear-spatulate, 3–4 mm. long; corolla densely white-pubescent without, its tube slender, 10–12 mm. long, cylindric, slightly expanded above, its lobes oblong-orbicular, rounded, deep purple above, 2.5–3 mm. long; capsule subglobose, 4–5 mm. in diameter.

Sancti Spiritus Mountains, Santa Clara; type from Sierra del Caballete (*Leon & Clement 6560*).

19. RONDELETIA CHAMAEBUXIFOLIA Griseb. Cat. Pl. Cub. 128. 1866

Rondeletia avenia C. Wright; Sauvalle, Anales Acad. Habana **6**: 121. 1869.

TYPE LOCALITY: Western Cuba.

DISTRIBUTION: Known only from the type locality, this not definitely recorded.

20. **Rondeletia intermixta** sp. nov.

A shrub, 1.6 m. high, the young twigs densely strigose-pubescent. Stipules triangular-ovate, pubescent, acute, persistent, spreading, about 2 mm. long; leaves oblong, chartaceous, 3–6 cm. long, acute at both ends, dark green and glabrous above, pale green and densely pubescent beneath, the midvein rather prominent, the lateral veins few, the slender petioles 8–15 mm. long; inflorescence axillary, short-peduncled, few–several-flowered, densely pubescent; bractlets ovate, acute, about 1 mm. long; calyx-teeth ovate, short; capsule globose, about 3 mm. in diameter, pubescent.

Gran Piedra, Oriente, at about 1,500 m. alt. (*Shafer 9039*). Apparently the same as a part of *C. Wright 1266*, recorded by Griesbach as *Rondeletia Poitaei* Griseb., but that name (Griseb. Fl. Br. W. I. 328) is a synonym of *Stevensia buxifolia* Poit., a plant known only from Hispaniola.

21. RONDELETIA LOMENSIS Urban, Symb. Ant. **7**: 394. 1912

TYPE LOCALITY: Dry serpentine hill, Loma Santa Teresa, near El Yunque, Oriente.

DISTRIBUTION: Known only from the type locality.

Dr. Shafer's notes describe this as a shrub about 2.6 m. high with white flowers; the corollas are not shown in the specimens.

22. **Rondeletia baracoensis** sp. nov.

Twigs slender, densely whitish-pubescent when young. Stipules triangular-ovate, acute, pubescent, about 2 mm. long; leaves chartaceous, elliptic, 2 cm. long or less, rounded or obtuse at the apex, narrowed or obtuse at the base, glabrous and obscurely veined above, whitish-tomentulose and reticulate-veined beneath with the primary venation prominent, the petioles 3–5 mm. long; peduncles opposite, rather stout, 1–3-flowered, 3–13 mm. long; bractlets lanceolate, pubescent, somewhat shorter than the calyx; calyx 3 mm. long, its lobes ovate or ovate-oblong, obtuse, one half as long as the tube; corolla-bud densely white-pubescent.

Vicinity of Baracoa (*Pollard, Palmer & Palmer 245*).

23. RONDELETIA RIGIDA Griseb. Mem. Am. Acad. II. **8**: 505. 1862

TYPE LOCALITY: La Madelina [Oriente].

DISTRIBUTION: Known only from the type locality.

24. RONDELETIA NIPENSIS Urban, Symb. Ant. **7**: 393. 1912.

TYPE LOCALITY: Sierra Nipe, near Woodfred, Oriente, in pine-lands, 500–650 m. alt.

DISTRIBUTION: Pine-lands and deciduous woods of the Sierra Nipe, Oriente.

Dr. Shafer's notes show this to be a shrub about 1.3 m. high, with white flowers.

25. RONDELETIA RUGELII Urban, Symb. Ant. 7: 397. 1912

Rondeletia Poitaei microphylla Griseb. Cat. Pl. Cub. 128. 1866.

TYPE LOCALITY: near Matanzas.

DISTRIBUTION: Known definitely only from the type locality.

Rugel's label indicates that this is a shrub growing in rocks. The species is related to the following one. Grisebach considered the plant to be the same as *R. Berteriana* A. Rich. (not DC.), which was collected at La Cabana, Havana. *R. Berteriana* DC., of Hispaniola, is clearly different.

26. RONDELETIA COMBSII Greenm. Trans. Acad. St. Louis 7: 427, *pl. 34.* 1897

TYPE LOCALITY: Calicita [Santa Clara].

DISTRIBUTION: Hillsides, cliffs and rocky shores, Santa Clara; Havana. Endemic.

Plants with identical foliage have calyx-lobes ovate or lanceolate; Dr. Greenman's original description indicates that they may even be linear. A fruiting specimen from Bahia Honda, Pinar del Rio (*Wilson 9409*), is doubtfully referred to this species.

27. RONDELETIA CAMARIOCA C. Wright; Sauvalle, Anales. Acad. Habana 6: 102. 1869

TYPE LOCALITY: Savannas of Camarioca [Matanzas].

DISTRIBUTION: Serpentine barrens and savannas, in dry soil, Camaguey; Santa Clara; Matanzas. Endemic.

28. **Rondeletia insularis** sp. nov.

A much-branched shrub, about 2 m. high, the twigs densely appressed-pubescent. Stipules triangular-ovate, connate, pubescent, persistent, 2–3 mm. long; leaves gray-green, oblong or oblong-obovate, chartaceous, 3 cm. long or less, 7–10 mm. wide, glabrous and very obscurely veined above, delicately reticulate-veined and strigillose beneath, the stout petioles about 1.5 mm. long; peduncles solitary in the axils, stout, about as long as the petioles, 1-flowered, pubescent; bractlets ovate, acute, 1 mm. long; capsule globose, densely puberulent, 4–5 mm. in diameter; calyx-lobes ovate-oblong, obtuse, 1 mm. long.

Vicinity of Pueblo Romano, Cayo Romano, Camaguey (*Shafer 2444*).

29. **Rondeletia savannarum** sp. nov.

A shrub, about 2 m. high, the twigs densely appressed-pubescent. Stipules triangular, acute, finely pubescent, 1–1.5 mm. long; leaves oblong to oblong-elliptic, 2 cm. long or less, 6–10 mm. wide, coriaceous, obtuse at the apex, narrowed at the base, glabrous, dark green and obscurely veined above, silvery-puberulent beneath with the few veins rather prominent, the petioles about 1.5 mm. long; flowers solitary in the axils; peduncles stout, 2–3 mm. long; calyx-teeth linear with the base broadened, 3 mm. long, about as long as the calyx-tube; corolla-bud densely pubescent; capsule globose, densely puberulent, 4 mm. in diameter.

Barren savannas, southeast of Holguin, Oriente (*Shafer 1230*, type; *2933*).

30. RONDELETIA VENOSA Griseb. Cat. Pl. Cub. 128. 1866

TYPE LOCALITY: Near San Marcos, Bahia Honda [Pinar del Rio].

DISTRIBUTION: Known only from the type locality.

31. RONDELETIA HYPOLEUCA Griseb. Cat. Pl. Cub. 128. 1866

TYPE LOCALITY: Eastern Cuba, near Baracoa.

DISTRIBUTION: Rocky situations, Oriente. Endemic.

A plant with orbicular leaves 5–7 mm. long, collected in a rocky thicket between Camp La Barga and Camp San Benito at about 1,000 m. alt. (*Shafer 4121*), is referred to this species with hesitation.

32. **Rondeletia vacciniifolia** sp. nov.

A much-branched shrub 0.3–1.3 m. high, the young twigs densely appressed-pubescent. Stipules triangular, acute, connate, pubescent, 1.5–2 mm. long; leaves oblong, coriaceous, 6–12 mm. long, acute at both ends, or the apex obtuse and mucronate, glabrous on both sides or sparingly pubescent on the midvein beneath, the lateral venation obscure, the stout, pubescent petioles 1.5–3 mm. long; flowers solitary in the upper axils, the stout, pubescent peduncles about as long as the petioles; bractlets triangular-ovate, acute; calyx-teeth linear, 2–3 mm. long; capsule globose, pubescent, 5 mm. in diameter, reddish.

Rocky situations, mountains of northern Oriente. Type from rocky bank of river, vicinity of Camp San Benito at 900 m. alt. (*Shafer 4090*).

33. **Rondeletia bicolor** sp. nov.

A shrub about 1.7 m. high, the twigs ascending, slender, densely short-pubescent when young. Stipules triangular-lanceolate, rather abruptly attenuate from a broad base, short-pubescent, about 3 mm. long; leaves oblong or oblong-oblanceolate, coriaceous, 2–3 cm. long, acute or some of them obtuse at the apex, narrowed at the base, dark green, glabrous and very obscurely veined above, white tomentulose and prominently veined beneath, the pubescent petioles 2–4 mm. long; peduncles axillary, pubescent, in fruit about 3 mm. long; fruits solitary, globose, pubescent, about 3 mm. in diameter.

Loma de Ponciano, Sancti Spiritus Mountains, Santa Clara (*Leon and Clement 6717*).

34. **Rondeletia** (?) **tinifolia** Griseb. Cat. Pl. Cub. 129. 1866

TYPE LOCALITY: Western Cuba.

DISTRIBUTION: Sancti Spiritus Mountains, Santa Clara; pinelands and arroyos, Pinar del Rio. Endemic.

35. **Rondeletia** (?) **camagueyensis** sp. nov.

A shrub about 3 m. high, the young shoots densely appressed-pubescent. Stipules triangular, acute, about 3 mm. long; leaves ovate or elliptic-ovate, 3–4 cm. long, 3 cm. wide or less, membranous, acute at the apex, narrowed or obtuse at the base, sparingly short-pubescent and indistinctly veined above, loosely strigose-pubescent, especially on the prominent veins beneath, the stout, pubescent petioles 2–3 mm. long; capsule subglobose, 4–6 mm. in diameter.

Arroyo, savanna near Camaguey (*Britton & Cowell 13206*).

Imperfect material only was collected at the time of our visit to the locality in April, 1912.

OTHER SPECIES ATTRIBUTED TO CUBA

Rondeletia microdon DC. Prodr. 4: 408. 1830

Havana, collected by Ossa, according to De Candolle. Described as a glabrous species, with oval-oblong, short-petioled leaves acute at both ends, bipartite, persistent, obtuse stipules; corymbose peduncled flowers, the calyx truncate, with five short teeth. The genus of this plant was questioned by A. Richard (in Sagra, Hist. Cub. 11: 13), and I do not know any species which answers to the description.

Rondeletia americana L. Sp. Pl. 172. 1753

This, the type of the genus, is also recorded by De Candolle as found at Havana by Ossa, and Grisebach (Fl. Br. W. I. 327) mentions it as Cuban. I know the plant only from St. Vincent and Jamaica.

Rondeletia laevigata Ait. Hort. Kew. ed. 2, 1: 366. 1810

De Candolle mentions this also as found at Havana, but no species answering to the description is known to me from Cuba; Grisebach (Fl. Br. W. I. 328) indicates that it is from the island of Trinidad.

Rondeletia leptacantha DC. Prodr. 4: 410. 1830

Collected by Ossa, near Havana, according to De Candolle. Described as a plant with opposite spines, broadly oval, subacute leaves, the twigs and leaves subpilose when young, the slender peduncle as long as the leaves or longer, three- to five-flowered at the apex. No species of *Rondeletia* known to me answers the description. Grisebach (Cat. Pl. Cub. 133) refers the plant to *Chomelia fasciculata* Sw. [*Anisomeris fasciculata* (Sw.) Schum.], but this disposal of it is not satisfactory.

57. THREE ERIOCAULONS FROM THE ISLE OF PINES

Eriocaulon arenicola Britton & Small, sp. nov.

Plants 4–26 cm. tall, the scapes solitary or usually several together; leaves ascending or spreading, 1–8 cm. long, linear-attenuate, convex beneath, slightly concave above, glabrous; scapes slender, mostly 6-angled, slightly spirally twisted, each subtended by an obliquely opened sheath which is shorter than the leaves; heads dense, at first depressed-globose, later subglobose or ovoid-globose, becoming about 5 mm. in diameter, pubescent, whitish-gray; bracts of the involucre cuneate to obovate, the outer ones about 1.5 mm. long; flowers numerous, crowded; bracts very broadly cuneate, fully 1.5 mm. long, short-hairy at and near the apex; sepals of the staminate flowers concave, cuneate to obovate, about 1.5 mm. long, exceeding the corolla, pubescent at the apex; corolla-lobes minute, ovate to oblong-ovate, obtuse; anthers about 0.25 mm. long; sepals of the pistillate flowers about 1.5 mm. long, boat-like, keeled, pubescent near the top; petals oblong to oblong-spatulate, fully 1 mm. long; capsule reniform-didymous, fully 0.5 mm. wide: seeds oval, barely 0.5 mm. long.

White sand, vicinity of Los Indios (*Britton & Wilson 14179*).

This plant is related to *Eriocaulon sigmoideum* C. Wright. It differs from it in the larger size, the more compact heads, the more copiously pale-pubescent and longer bracts, the smaller staminate flowers, and the sepals of the pistillate flowers which are wider below the middle, instead of at the top.

Eriocaulon fusiforme Britton & Small, sp. nov.

Plants 3–6.5 cm. tall, the scapes tufted, usually densely so; leaves ascending or recurved, subulate-lanceolate, 1–2.5 cm. long, thinnish, concave, glabrous; scapes relatively slender, spirally twisted, prominently 5-angled, each subtended by an obliquely opened sheath which is shorter than the longer leaves; heads dense, fusiform, becoming 7–8.5 mm. long, acute, glabrous, brownish; bracts of the involucre ovate to oblong, obtuse, chartaceous, 2–3 mm. long; flowers numerous; bracts rhombic-ovate or rhombic-cuneate, mostly 2 mm. long, acute or short-acuminate, scarious, glabrous, or obscurely fine-pubescent; sepals of the staminate flowers spatulate to oblong-spatulate, about 1 mm. long, sometimes laciniate at the apex, about equalling the corolla or exceeding it; corolla-lobes ovate; anthers about 0.15 mm. long; sepals of the pistillate flowers about 1.5 mm. long, boat-shaped, strongly keeled and crested above the middle, acuminate; petals linear-elliptic to linear-spatulate, 1.5–2 mm. long; capsule suborbicular or orbicular-ovoid, about 0.5 mm. wide: seeds narrowly oval, about 0.5 mm. long.

Pinelands, Siguanea (*Britton & Wilson 14951*).

This differs from all described Cuban species of *Eriocaulon*. Its short stiff scapes and fusiform glabrous or nearly glabrous heads are particularly diagnostic.

Eriocaulon ovoideum Britton & Small, sp. nov.

Plants 6–11 cm. tall, the scapes tufted, usually densely so; leaves erect or ascending, narrowly linear-lanceolate to linear-attenuate, 1–3 cm. long, concave, thinnish, glabrous; scapes stoutish, spirally-twisted, sharply 5-angled, each subtended by an obliquely opened sheath which is as long as the leaves or shorter; heads very dense, ovoid or globose-ovoid, becoming 6–8 mm. long, obtuse, tan-colored; bracts of the involucre ovate to oblong, 1.5–3 mm. long, obtuse, glabrous, chartaceous; flowers numerous; bracts subreniform, mostly wider than long, broadly rounded at the apex, scarious, minutely pubescent; sepals of the staminate flowers obovate to cuneate, concave, fully 1 mm. long, erose at the apex, mostly exceeding the corolla; anthers ovoid, about 0.1 mm. long; sepals of the pistillate flowers boat-shaped, fully 1 mm. long, keel-winged and crested on the back, abruptly pointed: petals spatulate, about 1.5 mm. long, often erose at the apex; capsule reniform, about 1 mm. wide; seeds broadly oval, fully 0.5 mm. long.

White sand, vicinity of Los Indios (*Britton & Wilson 14220*).

Related to *Eriocaulon fusiforme*, differing in stouter habit, the short and broad heads, and in the broad and rounded bracts.

58. UNDESCRIBED CUBAN SPECIES

Dupatya montana sp. nov.

Stem simple, elongate, stout, densely leafy. Leaves broadly linear, 8–14 cm. long, 6–15 mm. broad at the base, narrowed to the acute apex, rigid, glabrous, striate-nerved; peduncles erect, 15–30 cm. high, often numerous, axillary, loosely pubescent with long, soft, white hairs, or glabrous; sheaths shorter than the leaves, acuminate; heads solitary on the peduncles, hemispheric, 7–8 mm. broad; outer involucral bracts ovate, the inner ones broadly oval to orbicular, rigid, acute, glabrous; receptacle pilose, the bracts membranaceous, obovate-cuneate, 1.8–2 mm. long, 0.6–0.8 mm. broad, with a tuft of short hairs on the back at the apex; staminate flowers dimerous; sepals spatulate-obovate, about 1.9 mm. long, concave, ciliate at the apex; pistillate flowers dimerous; sepals elliptic, concave; stigmas 2; ovary globose-ovate.

Collected on compact red iron ore along trail from Rio Yamaniguey to Camp Toa, Oriente, at 400 m. alt. (*J. A. Shafer 4473*, type); also collected along trail from Camp La Barga to Camp San Benito (*Shafer 4104*) and at Camp La Gloria, south of Sierra Moa (*Shafer 8045, 8251*).

Apparently closely related to **Dupatya pungens** (Griseb.) Britton (*Paepalanthus pungens* Griseb.), another Cuban species.

Pilea Cowellii sp. nov.

Glabrous, perennial, monoecious, about 4 dm. tall; stem becoming more or less grooved and compressed in drying, clothed with numerous, small, elliptic raphides; leaves elliptic to ovate, or the uppermost oblong-obovate, 1–3 cm. long, 0.7–1.1 cm. broad, acute or obtuse at the apex, rounded and more or less cordate at the base, 3-nerved, green and lustrous above, paler beneath, with prominent, scattered, elevated callosites when fresh which become depressed in drying, entire; raphides of the upper surface linear, those of the lower surface punctiform; petioles 1–2 mm. long; inflorescence axillary, 1–2 cm. long, equalling or shorter than the leaves; staminate and pistillate flowers intermixed; staminate flowers: pedicels 0.5 mm. long, perianth glabrous, 1 mm. long, the lobes triangular-ovate; stamens 4; pistillate flowers short-pedicelled or subsessile.

Type collected on cliffs, Ensenada de Mora, Oriente (*Britton, Cowell & Shafer 12977*).

Ichthyomethia havanensis Britton & Wilson, sp. nov.

A shrub 2 m. tall, with finely pubescent twigs; leaves odd-pinnate, 1–1.4 dm. long, the petioles, rachis and petiolules velvety-ferruginous when young; leaflets 9–13, elliptic to somewhat elliptic-obovate, 2.3–4.5 cm. long, 1.3–1.7 cm. broad, acute to rounded and often apiculate at the apex, rounded at base, short-petioluled, densely clothed with short, appressed, silky hairs when young, in age glabrous or nearly so above, finely pubescent and reticulate-veined beneath; calyx campanulate, pubescent with short, appressed brownish hairs; pods broadly 4-winged, puberulent with appressed hairs, 2–3.5 cm. long, 2–2.8 cm. broad, stipitate, the margin more or less undulate; seeds oblong, 5 mm. long, 2.5–3 mm. broad.

Related to *I. piscipula* (L.) A. S. Hitchc., but differing in the much smaller and more coarsely reticulate leaflets, and smaller fruit.

Thickets not far from Cojimar, Province of Havana (*Brother Leon & Father M. Roca 6194*, type); also collected on a hill west of Chorrera, Province of Havana (*Brother Leon 5192*).

Castelaria calcicola Britton & Small, sp. nov.

A much-branched shrub up to 2.5 m. tall, with stout thorns which are branched when well developed, the twigs closely fine-pubescent; leaf-blades obovate, varying to oval or ovate, mostly 1.5–4 cm. long, rounded or retuse and mucronulate at the apex, entire, slightly revolute and reticulate in age, bright green above, paler beneath, somewhat shining, minutely pubescent, especially on the midrib and veins beneath, short-petioled; flowers several in each cluster, short-pedicelled, the pedicels densely pubescent; sepals triangular-ovate, about 1 mm. long, green, acutish, copiously pubescent; petals ovate or oval, concave, cymbiform, 3.5–4 mm. long, red, sparingly pubescent on the back; filaments subulate, nearly 2 mm. long, villous-tomentose; anthers slightly longer than the filaments, oblong, or nearly so; drupes flat, fully 1.5 cm. long, nearly as wide, about 6 mm. thick, bright-red, the flesh thin, with a fibrous-reticulate network which is impressed into the putamen.

Limestone hills, vicinity of Sumidero, Pinar del Rio (*Shafer 13434*).

This shrub is related to *Castelaria jacquinifolia*. It differs from that species in the pubescent leaves, the triangular-ovate sepals, the pubescent petals, and the narrower and longer anthers.

Stenostomum obovatum sp. nov.

A straggling tree, the slender twigs glabrous. Leaves coriaceous, obovate, 6 cm. long or less, rounded at the apex, narrowed at the base, revolute-margined, faintly shining, the midvein impressed above, prominent beneath, the lateral venation slender and obscure, the stout petioles 3–5 mm. long; inflorescence terminal; fruits in pairs, sessile, oblong, black, fleshy, 10–12 mm. long, 5–7 mm. thick.

Camp La Gloria, south of Sierra Moa, Oriente (*Shafer 8169*).

Stenostomum aristatum sp. nov.

A rough-barked tree about 6 m. high, with widely spreading branches, the slender young twigs resinous. Stipules broadly ovate, obtuse, 3 mm. long, caducous; leaves elliptic or ovate-elliptic, coriaceous, 2.5 cm. long or less, acute and aristate at the apex, mostly obtuse at the base, shining and strongly reticulate-veined on both surfaces, especially above, the margins slightly revolute, the petioles 1–2 mm. long; peduncles solitary in the uppermost axils, about one-half as long as the leaves, 1- to 3-flowered at the apex; flowers fragrant; calyx narrowly campanulate, 5 mm. long, 5-lobed, the lobes oblong or oblong-obovate, 1.5–2 mm. long, rounded; corolla white, its tube narrowly cylindric, about 2 cm. long, 1 mm. thick, its limb spreading, 5-lobed, about 1 cm.

broad, the lobes rounded; stamens 5; anthers linear, 2 mm. long; ovary 6-celled.

Rocky hill, savanna near Camaguey (*Britton & Cowell 13241*).

59. NOTES ON VARIOUS SPECIES

Evolvulus siliceus Britton & Wilson, nom. nov.

Evolvulus arenicola Britton & Wilson, Bull. Torrey Club **43**: 466. 1916. Not *E. arenicola* Johnston, 1905.

PERSICARIA HIRSUTA (Walt.) Small

Marsh near Ferry River, Jamaica (*Britton 394*). Hitherto unrecorded from Jamaica.

PHENAX SONNERATII (Poir.) Wedd.

Gravelly soil, Jamaica (*Alex. E. Wright 193*). Hitherto unrecorded from Jamaica.

PHYLLANTHUS NUMMULARIAEFOLIUS Poir.

Shady places, Hope Grounds, Jamaica (*Harris 12123, 12157, 12208*). Hitherto unrecorded from Jamaica.

VERONICA TOURNEFORTII Gmelin

Waste and shaded grounds, near Mandeville (*Crawford 683*) and near Cinchona, Jamaica (*Harris 12417*).

JACQUINIA KEYENSIS Mez.

Northern coast of Camaguey and Matanzas provinces, Cuba (*Shafer 689, 2593, 2712; Britton & Wilson 14043*); Little Goat Island, Jamaica (*Britton 1852*); Albion Mountain, Jamaica (*Harris 11678, 12199*). Heretofore recorded from the Bahamas and Florida.

CYRILLA BREVIFOLIA N. E. Brown

Mountains of northern Oriente, Cuba (*Shafer 4060, 4054, 4109, 4140, 4181, 8032*). Apparently identical with the plant of Mt. Roraima, British Guiana (Trans. Linn. Soc. II. **6**: 22. *pl. 1, f. 7–16*).

STEMODIA PARVIFLORA Ait.

Rio Piedras, Porto Rico (*Stevenson 2178*). Hitherto unrecorded from Porto Rico.

DITTA MYRICOIDES Griseb.

Sierra de Naguabo, Porto Rico (*Shafer 3603*). Hitherto unrecorded from Porto Rico.

SIDA EGGERSII E. G. Baker

Island of Culebra, Porto Rico, 1906 (*Britton & Wheeler 178*). Hitherto known only from Tortola, where Dr. Shafer made a second collection of it in 1913. A tree, 6–8 m. high, very different from typical species of *Sida*.

OSSAEA DOMINGENSIS Cogn.

Alto de la Bandera, Porto Rico (*F. L. Stevens 8717*). Hitherto known only from Santo Domingo.

LESCAILLEA EQUISETIFORMIS Griseb.

This monotypic genus of Compositae was rediscovered on the southern slope of Cajalbana in the province of Pinar del Rio, Cuba, by Brothers Leon and Charles on April 6, 1915. The genus has hitherto been imperfectly known, as it was represented in this country only by a fragment at the Gray Herbarium, collected by Charles Wright in western Cuba. *Lascaillea* is a woody vine related to *Porophyllum*. The leaves are reduced to small scales, the plant resembling certain species of *Ephedra* much more closely than it does any *Equisetum*.

A quantitative, volumetric and dynamic study of the vegetation of the Pinus Taeda belt of Virginia and the Carolinas

ROLAND M. HARPER

(WITH ONE TEXT FIGURE)

Introduction. The study of the vegetation of a given region may conveniently be divided into four stages. First, the various species of plants are collected, described (if necessary), and classified taxonomically, and their local distribution determined. Second, they are classified "ecologically," by habitat, associations and adaptations, and the environmental factors analyzed. Third, their relative abundance is determined, in the region as a whole or in each habitat separately, and estimates made of the percentages of evergreens, vines, parasites, plants belonging to certain families, etc. Fourth, the total bulk or weight of vegetation per unit area may be measured, together with the amount of new growth made in an average year, and the amount of water and other substances taken from the soil at the same time.

Although this is perhaps the usual and most convenient order, and also corresponds pretty well with the historical development of the science of plant sociology,* it is by no means a fixed order. Any one of the stages may be omitted, and the fourth, which though rather difficult is simple enough, could very well precede the first. And of course it is not to be assumed that the foregoing outline covers everything that needs to be known about vegetation. For example, it takes no account of generalizations about geographical distributions, times of flowering, colors of flowers, pollination and dissemination, studies of endemism and bibliographic history, and speculations about geological history and succession, all of which have contributed many pages to the botanical literature. Comparisons with similar or neighboring regions are always appropriate, too.

The region under consideration offers little attraction to the botanist who does not go beyond the first stage, and "cannot see the woods for the trees." As seems to be the case wherever *Pinus Taeda* (and the same might be said of several other pines) is the prevailing tree,* nearly all the plants are of common and widely distributed species, which have been described long ago. In the second stage, very little has been done in this region, largely because of inherent difficulties which will be explained below under the head of vegetation. This paper is chiefly concerned with the third stage, determining the relative abundance of the species in the region as a whole, which is done by means of notes accumulated during about seventy-five hours of field work. For the fourth stage, volumetric and dynamic studies, very few accurate data are available as yet for this or any other part of the world, but some rough estimates are attempted, to illustrate a method which should be followed in all future critical studies of vegetation. For it cannot be disputed that the annual growth of vegetation, and particularly the amount of food taken from the soil in a given time, is closely correlated with enviromental factors, and should be a better indication of soil fertility than any static studies of vegetation, whether qualitative or quantitative.

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* See Torreya 16: 138. June, 1916.

Location and boundaries of the region. The *Pinus Taeda* belt proper of the Atlantic coastal plain, as mapped by the writer a few years ago† (in FIG. 1 the same map is reproduced), is regarded as bounded on the north by the James an Appomattox Rivers. From Petersburg, Va., to the vicinity of Rocky Mount, N. C., it borders the fall-line, which there (as all the way across Virginia) runs just about north and south. Thence to near Fairfax, S. C., it passes northwestward into a belt of low red hills, a continuation of the Eocene red hills of Georgia, Alabama and Mississippi. From Fairfax to near Charleston it is bounded on the south by the pine-barrens with *Pinus Elliottii;* thence to near the mouth of the Santee River it is separated from the coast by a narrow coast strip, with marshes, islands, and a good deal of silty soil. From Horry County, S. C., to Onslow County, N. C., it passes gradually southeastward into the Wilmington or Cape Fear pine-barrens, with a much larger proportion of *Pinus palustris* and less *P. Taeda*. From Carteret County, N. C., to Nansemond County, Va., the Nansemond escarpment, parallel to the Virginia fall-line,* separates it from the region of oak and beech flats with more silty soil, in which Dismal Swamp is situated. In South Carolina the belt under consideration corresponds approximately with the "upper pine belt" of Hammond and other nineteenth century geographers.

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* See Torreya 7: 44–45. 1907; 9: 217. 1909. This applies to habitats, though, rather than to regions. For example, *Pinus Taeda* is the commonest tree in the Apalachicola bluff region of Middle Florida (see 6th Ann. Rep. Fla. Geol. Surv. 212–215, 353, 355), where many rare plants grow; but the pine is mostly near the top of the bluffs and the rare plants lower down.

† Bull. Torrey Club 37: 407, 592. 1910–11.

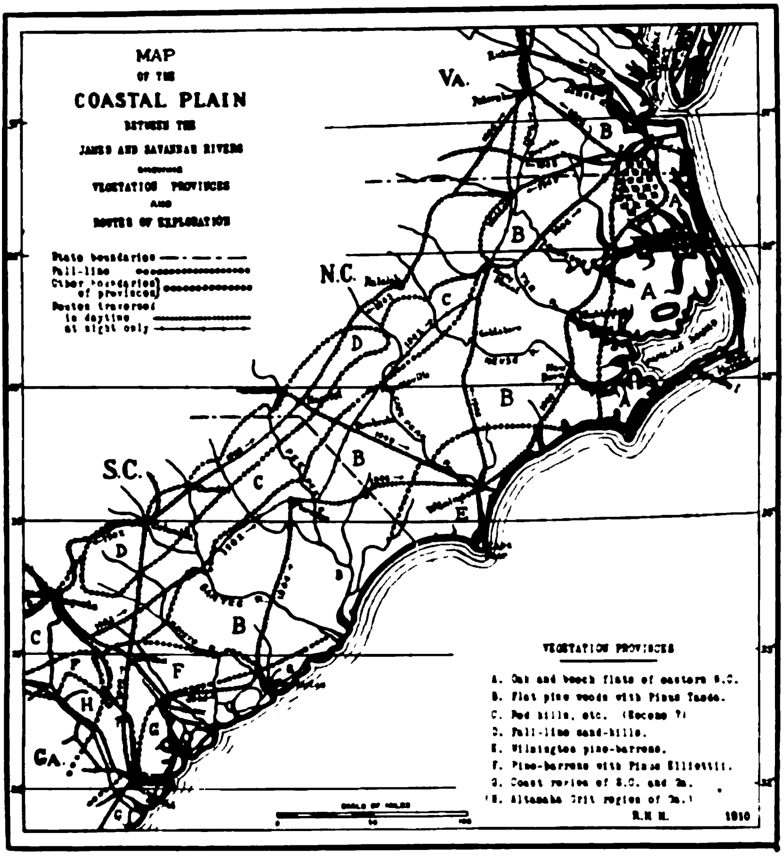
MAP
OF THE
COASTAL PLAIN
BETWEEN THE
JAMES AND SAVANNAH RIVERS
SHOWING
VEGETATION PROVINCES
AND
ROUTES OF EXPLORATION
State boundaries
Fall-line
Other boundaries of provinces
Routes traversed
in daytime
at night only
VA.
N.C.
S.C.
GA.
A
B
C
D
E
F
G
H
VEGETATION PROVINCES
A. Oak and beech flats of eastern N.C.
B. Flat pine woods with Pinus Taeda.
C. Red hills, etc. (Eocene ?)
D. Fall-line sand-hills.
E. Wilmington pine-barrens.
F. Pine-barrens with Pinus Elliottii.
G. Coast region of S.C. and Ga.
(H. Altamaha Grit region of Ga.)
SCALE OF MILES
R.M.H.
1910

FIG. 1.

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* See Hobbs, Rep. 8th Int. Geog. Cong. (1905), line III on map opposite p. 196.

In the present paper the red hill belt lying just southeast of the fall-line sand-hills in the Carolinas is combined with the flatter and more sandy *Pinus Taeda* belt, being connected with it apparently by imperceptible gradations, and not differing much in vegetation. The total area involved is about 28,000 square miles. The most important literature on the region was summarized by the writer in 1907.* Since then there have been published several more government soil surveys, a report on the geology of the coastal plain of North Carolina,† Coker's Plant Life of Hartsville, S. C.,‡ and Ashe's monograph on loblolly or North Carolina pine.§ C. S. Chapman's "A working plan for forest lands in Berkeley County, South Carolina,"|| which was cited in my 1907 paper, will be referred to more specifically below.

Topography and hydrography. The altitude ranges from sea-level to about 300 feet. The topography is gently undulating in the red hills and nearly flat elsewhere, with few railroad cuts deep enough to obstruct the view of the traveler on a passenger train. There are bluffs near some of the rivers, but all the streams are bordered at least on one side by swamps, whose width is approximately proportional to the size of the stream. The rivers which rise in the Piedmont region are muddy, but the smaller streams which are confined to the coastal plain are not, except in prolonged wet weather. In the flat areas are many very shallow depressions, which will be referred to again under the head of vegetation. The ground-water is nearly everywhere close enough to the surface to be reached by well-sweeps and suction pumps.

Soils. The average soil might be described as a grayish sandy loam, varying toward red clay in the higher portions, and purer sand near some of the rivers. According to the government soil surveys hitherto published for this region (none for Virginia, about nine for North Carolina and eight for South Carolina), the eight commonest types of soil in the North Carolina portion are

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* Bull. Torrey Club 34: 351–353. 1907.

† N. C. Geol. Surv., Vol. 3. 552 pp. "1912." (Published about the middle of 1913.)

‡ See Torreya 13: 139–144. 1913.

§ N. C. Geol. Surv. Bull. 24. 169 pp., 27 pl. 1915.

|| U. S. Bur. Forestry Bull. 56. 62 pp., 4 plates & map. "1905." See Bull. Torrey Club 34: 352 (5th footnote), 360 (4th footnote). 1907.

"Norfolk fine sandy loam,"* "Norfolk sandy loam," "Swamp," "Norfolk sand," "Portsmouth fine sandy loam," "Portsmouth sand," "Portsmouth sandy loam," and "Norfolk fine sand"; and in the South Carolina portion "Norfolk sandy loam," "Swamp," "Portsmouth sandy loam," "Norfolk sand," "Coxville fine sandy loam," "Norfolk fine sandy loam," "Portsmouth fine sandy loam," and "Orangeburg fine sandy loam." This sequence should not be taken too literally, for the areas that have been surveyed may not be perfectly typical, and moreover, there are all possible gradations between adjacent soils, and similar soils are very liable to be classified a little differently by different men in neighboring areas, or even by the same men in different years. But it will suffice to show the prevalence of gray sandy loams and of swamps, and the scarcity of reddish and distinctly clayey soils. The reddish "Orangeburg" soils are perceptibly commoner in South Carolina than farther northeast.

The physical composition of the soil may also be illustrated by disregarding the more or less arbitrary series names (thus eliminating much of the "personal equation") and summing up the ten commonest texture classes, with their percentages. As in the plant list farther on, the column of percentages preceding the names is for the whole area, and the others for separate states as indicated.

	SOIL TYPES	N. C.	S. C.
31.2	Sandy loam	26.1	37.0
22.4	Fine sandy loam	30.0	12.7
15.0	Sand (including sand-hill)	13.9	16.0
14.0	Swamp, muck, etc.	14.8	12.6
3.8	Fine sand	3.8	3.8
3.0	Clay	1.8	4.2
2.7	Coarse sandy loam	1.5	4.1
2.4	Coarse sand	2.2	2.5
2.3	Loam	1.1	3.8
1.5	Very fine sandy loam	2.1	0.7

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* For the benefit of readers who are not familiar with the system of classification used by the U. S. Bureau of Soils it should be explained that the "Norfolk" series includes grayish coastal plain soils with friable yellowish subsoils, the "Orangeburg" gray, red or brownish soils with sandy clay subsoils, and the "Portsmouth" damp blackish more or less peaty soils with flat or slightly depressed surface. "Swamp" is usually applied to permanently saturated soils, but does not include all kinds of swamps, some of which have been described under other names, especially in later years.

Data for estimating the average chemical composition of the soil are rather meager. In the Tenth Census, vol. 6, pp. 504 and 556, are analyses of seven soils from this region (five from North Carolina and two from South Carolina), made by Hilgard's five-day acid digestion method, which seems to give results more consistent with the vegetation and crops than any earlier or later method. Details of the locality, depth, vegetation, etc., of each soil are given in the work mentioned (under Nos. 1 and 9 on page 504 and 11, 13, 15, 17 and 19 on page 556), and need not be repeated here. The averages of the seven analyses are given below. (With so few samples from South Carolina and none from Virginia it would hardly be worth while to give the averages for each state separately.)

	Per cent.
Water and organic matter	2.940
Potash (K_2O)	.125
Soda (Na_2O)	.052
Lime (CaO)	.079
Magnesia (MgO)	.076
Phosphoric acid radicle (P_2O_5)	.082
Sulphuric acid radicle (SO_3)	.085
Brown oxide of manganese (Mn_3O_4)	.068
Peroxide of iron (Fe_2O_3)	1.684
Alumina (Al_2O_3)	3.375
Soluble silica	2.704
Insoluble matter	88.844

These figures of course will mean little to one who is not accustomed to interpreting soil analyses, but those who are sufficiently interested may find it worth while to compare them with similar analyses from other states published in the same work and copied by the writer in recent easily accessible publications.* Even yet the significance of some of the figures cannot be explained, for lack of knowledge of the functions of some of the soil constituents in plant physiology; but there is no doubt that these soils are below the average for the United States in fertility.

It seems very probable that the Virginia portion of this belt has a higher proportion of potassium in its soil than the rest, on account of the proximity to metamorphic rocks and the drier summers, and more humus on account of the richer soil and less frequent fires. South Carolina is probably above the average in calcium, phosphorus and iron, on account of the occurrence of those elements in the underlying strata.

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* Bull. Torrey Club 40: 380–391. 1913; 41: 555. 1914; Rep. Fla. Geol. Surv. 6: 195, 230, 269, 328. 1914; 7: 123. 1915.

Another pretty good indication of soil fertility or the lack of it is the density of population, proportion of "improved land," and the annual expenditure per acre for fertilizers.[*] In the table below these data are given for the portions of the belt under consideration in each state, and also for the whole of each state and the United States, as computed from the reports of the 10th and 13th censuses.[†]

Areas	Inhabitants per square mile		Percentage of improved land		Expenditure for fertilizer per acre	
	1880	1910	1880	1910	1879	1909
Pinus Taeda belt:						
Virginia	29.4	40.7	25.9	28.1	$0.45	$1.89
North Carolina	28.8	42.0	19.8	27.2	.41	2.67
South Carolina	27.5	41.0	18.4	30.0	.73	3.47
Whole states:						
Virginia	37.7	51.2	33.0	38.3	.25	0.70
North Carolina	28.7	45.3	20.8	28.2	.33	1.39
South Carolina	32.0	49.7	21.2	31.3	.64	2.49
Whole United States	16.9	30.9	15.0	25.1	.10	0.24

These statistics ought to make it plain enough that the soil of the *Pinus Taeda* belt is less fertile than the average of the states in which it lies, and that in this belt the soil fertility tends to decrease a little southward. The great increase in the use of fertilizers between 1880 and 1910 probably does not indicate soil exhaustion so much as that the greatly increased output of the nitrate, phosphate and potash mines in other parts of the world, together with the improvement of transportation facilities, makes it possible to cultivate with profit much poorer soils than formerly.

Climate. As far as climate is concerned it will probably suffice for present purposes to give for one station in each state the mean temperature for January, July and the year, in degrees Fahrenheit, the average annual precipitation, in inches, and the percentage of it that comes in the four warmest months (June to September) and six warmest months (May to October). The stations selected are Williamsburg, Va., Goldsboro, N. C., and Blackville, S. C., at each of which records have been kept for more than twenty years. The figures have been computed from the annual summaries of the U. S. Weather Bureau for 1913, except that a few obvious typographical errors have been corrected with the aid of the 1912 summaries. There happens to be no station within the Virginia portion of the *Pinus Taeda* belt with a sufficiently complete record, but Williamsburg is only a short distance away, on the north side of the James River.

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[*] See Science II. 42: 500–503. Oct. 8, 1915.

[†] For some similar statistics for other southeastern states and their economic significance, with a map of the pine-barren region, see Journal of Geography 14: 42–48. Oct. 1916.

Stations and length of record	Mean temperature			Average Precipitation		
	Jan.	July	Annual	Annual	4 mos.	6 mos.
Williamsburg, Va., 22 years....	38.4°	76.8°	57.1°	49.18	38.6%	51.9%
Goldsboro, N. C., 44 years.....	42.3°	79.8°	61.1°	51.85	45.0%	60.0%
Blackville, S. C., 25 years......	46.4°	81.7°	64.4°	47.47	44.3%	58.3%

The milder winter southward is of course not surprising. The proportion of summer rain is higher here than in most places a little farther inland, but lower than in the neighboring Cape Fear pine-barrens.* The wetness of the summers in North Carolina, especially as compared with Virginia, is significant, and helps explain some of the differences in soil and vegetation.

Vegetation. The prevailing type of upland vegetation in this region resembles the typical pine-barrens farther south except in having more *Pinus Taeda* than *Pinus palustris*, more deciduous trees, and more shrubs. The flat areas and shallow depressions previously mentioned generally have either pocosin or cypress pond vegetation, the former being commonest in North Carolina (but more characteristic of the Cape Fear pine-barrens) and the latter in South Carolina.† Both alluvial and non-alluvial swamps,

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* For similar data for other places see Bull. Torrey Club **37**: 415–416. 1910; **41**: 556–557. 1914; Rep. Fla. Geol. Surv. **6**: 182–183. 1914.

† The "savannas" described by Chapman and the "bays" described by Coker, in the works on South Carolina vegetation already cited, must be very similar to pocosins, while Chapman's "pocosins" and Coker's "savannas" seem to be essentially cypress ponds. This does not necessarily indicate that these authors used the terms incorrectly, but rather that local usage varies from place to place. Readers who are not familiar with the term "pocosin" can find references in Bull. Torrey Club **37**: 415 (first footnote). 1910; and New Internat. Encyc. II. **18**: 761. 1916.

July 19, 1908. Suffolk to Emporia, Va., by the Southern Ry. (Torreya 9: 219–221, 223–226. Nov. 1909.)

July 26, 1909. On the Seaboard Air Line in southwestern South Carolina from the Salkehatchie River to the North Fork of the Edisto. (Bull. Torrey Club 37: 403–406, 411, 413–414, 418–420. 1910. This covers the work of the next two days also.)

July 27, 1909. Laurel Hill to Rosindale, N. C., by the Seaboard Air Line, and Verona to New Bern by the Atlantic Coast Line.

July 28, 1909. New Bern to Mackey's Ferry, N. C., by the Norfolk & Southern Ry. (now Norfolk Southern R. R.).

March 4, 1910. Perry to Allendale, S. C., by the Southern Ry. (Bull. Torrey Club 38: 225–226. 1911.)

Aug. 22, 1913. Aiken to Ashley Junction, S. C., by the Southern Ry., with a stop of about an hour at Branchville, which allowed some observations on weeds. (Torreya 16: 243. 1916.) Ashley Junction to Florence, S. C. (same route as on July 26, 1906) later in the day.

Aug. 23, 1913. Florence, S. C., to Parkton, N. C., and Fayetteville to Selma, N. C., by the Atlantic Coast Line. Selma to Goldsboro by the Southern Ry. Goldsboro to Beaufort, N. C., by the Norfolk Southern R. R., but note-taking interrupted by darkness near Mansfield, about 89 miles from Goldsboro.

Aug. 26, 1913. Beaufort to Kinston, N. C., by the Norfolk Southern R. R., and on foot from Kinston to Dover and the big pocosin near by. (See Pop. Sci. Monthly 85: 354. Oct. 1914.)

Aug. 27, 1913. Kinston to Halifax, N. C., by the Atlantic Coast Line. (Notes taken later in the day along or near the fall-line north of Halifax are not counted here.)

March 3, 1914. North Fork of the Edisto to the Salkehatchie River in South Carolina, by the same route as on July 26, 1909, at the rate of about 44 miles an hour.

Dec. 16, 1915. Florence, S. C., to Pembroke, N. C., by the Atlantic Coast Line, and on foot along the Seaboard Air Line for a few miles northwest of Pembroke, to get one of the same plants seen there in 1905.

These trips together comprise about 1,560 miles of railroad travel in 53 hours (including perhaps 200 stops of half a minute or more at stations), and 40 miles of walking in 21 hours; and touch about five-sixths of the counties in the whole region. By states the field work might be summed up as follows: Virginia, one day in June and three in July; North Carolina, one in June, four in July, three in August, one in November, one in December; South Carolina, two in March, four in July, two in August, one in December. If observations could have been made in April, May, September and October the list of herbs would be more complete and accurate, but it is not likely that any tree that makes up as much as 1 per cent of the vegetation has been overlooked, except in cases of closely related species that are difficult to distinguish.

Methods of Analysis. Notes on the vegetation were taken on practically every mile, and from these the percentages given below have been calculated. As car-window notes cannot do justice to the abundance of some of the conifers, I have arbitrarily multiplied my figures for *Pinus Taeda* and *P. palustris* by 5 and for other conifers by 3 before calculating the percentages. The figures for *Cornus florida*, *Salix nigra*, *Oxydendrum*, *Carpinus* and *Planera* have been divided by 2 on account of the small size of those trees, for the object of this study is to analyze the vegetation volumetrically. The figures for a few still smaller trees, or large shrubs (listed after the regular trees) have been divided by 10, those for ordinary shrubs and woody vines by 100, and those for herbs by 500.* Species seen less than five times, which are presumed to make up a wholly insignificant part of the total vegetation, are omitted, as are all bryophytes and thallophytes, which are still smaller and less conspicuous, on the average, than vascular herbs. The fact that nearly all my walking in this region has been done in North Carolina tends to exaggerate the shrubs and herbs in the middle portion, but allowance is made for that in the generalizations which follow the list.

These percentages of course cannot be guaranteed to be accurate within 10 per cent., but they are reasonably consistent with pre-conceived notions and known facts. In C. S. Chapman's report on Berkeley County, S. C., previously mentioned, there is a multitude of detailed statistics from which the percentages of the commoner trees in that particular area can be computed, and that serves as a check on my results. But his figures cannot be taken as representative of the whole *Pinus Taeda* belt, for several reasons. In the first place, his area is too small and too far from the center to be thoroughly typical, and being the property of a lumber company it probably contains more pine than the average. Second, some of the species are wrongly identified,† and some very common ones, such as *Pinus serotina* and *Quercus marylandica*, are omitted from the statistics though mentioned as occurring.

The species are arranged in order of abundance in the region as a whole, but the percentages are given separately for each of the three states involved, in order to bring out certain interesting features of local distribution. The total percentage is given first, then the name of the species, its usual habitat in the region, and the percentages for the three states. Percentages too small to be represented without using too many decimal places are replaced by o, but where a species has not been seen at all in one of the states the space is left blank. Percentages are given for herbs only in the case of a few of the most abundant species, for to attempt it for all of them would be a refinement wholly unwarranted by my crude methods, and would require too long decimals. The highest number in each line, if it is reasonably certain that more thorough exploration will not overturn its plurality, is printed in heavier type, so that the reader can run down one column at a time and pick out the characteristic species for each state. The names of evergreens are printed in heavier type (in the case of semi-evergreens only the specific name), and those of weeds enclosed in parentheses.

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* This is a modification of a method described in the 6th Annual Report of the Florida Geological Survey, pp. 177–180.

† See Bull. Torrey Club **34**: 352. 1907.

LIST OF PLANTS

TREES

			Va.	N. C.	S. C.
46.4	**Pinus Taeda**	Nearly everywhere	**58.1**	49.9	40.4
16.4	**Pinus palustris**	Driest soils	0	12.1	**25.6**
6.2	**Pinus serotina**	Damp sandy places	1.0	**8.3**	4.7
3.7	Taxodium distichum	Richer swamps	**8.7**	3.3	3.1
3.4	Liquidambar Styraciflua	Various habitats	**5.5**	3.7	2.6
3.3	Nyssa biflora	Ponds and swamps	1.8	**4.0**	2.9
3.3	Taxodium ascendens	Ponds and small swamps	—	3.1	**4.5**
1.7	Quercus marylandica	Driest soils	0.8	1.8	1.7
1.6	**Pinus echinata**	Driest soils	**7.8**	0.7	1.3
1.5	Liriodendron Tulipifera	Branch-swamps mostly	**2.5**	1.6	1.3
1.4	Acer rubrum	Swamps	1.0	**1.7**	1.2
1.4	**Magnolia glauca**	Non-alluvial swamps	1.8	1.7	1.1
0.8	Quercus falcata	Dry soils	0.9	1.1	0.4
0.8	Quercus Catesbaei	Dry sandy soils	0.1	0.5	**1.2**
0.6	Nyssa uniflora	Alluvial swamps	**1.9**	0.5	0.5
0.6	Cornus florida	Uplands	**0.9**	0.8	0.3
0.5	Quercus alba	Richer soils	**1.9**	0.7	0.1
0.5	Quercus Phellos	Low grounds mostly	0.3	0.5	**0.6**
0.5	Salix nigra	Along streams mostly	**0.9**	0.6	0.4
0.4	Quercus **nigra**	Low grounds mostly	0.2	0.3	**0.5**
0.3	Quercus stellata	Uplands	0.2	0.4	0.3
0.3	Betula nigra	Along creeks and rivers	**0.5**	0.3	0.3
0.3	Oxydendrum arboreum	Uplands	**0.6**	0.4	0
0.2	**Ilex opaca**	Hammocks, etc	**0.6**	0.2	0.2

0.2	Fagus grandifolia	Hammocks, etc.	0.2	0.2	0.1
0.2	(Diospyros virginiana)	Old fields, etc.	0.5	0.2	0.1
0.2	Fraxinus caroliniana	Swamps	—	0.1	0.2
0.1	Quercus Michauxii	Bottoms, etc.	0	0.1	0.2
0.1	Hicoria alba?	Richer soils	—	0.1	0.2
0.1	Hicoria aquatica	Alluvial swamps	0.1	0.1	0.2
0.1	Platanus occidentalis	Alluvial swamps	0.5	0.1	0.1
0.1	Quercus cinerea	Sandy uplands	—	0.1	0.2
0.1	Gordonia Lasianthus	Non-alluvial swamps	—	0.2	0
0.1	Juniperus virginiana		—	0.1	0.1
0.1	Populus heterophylla	Alluvial swamps	—	0	0.1
0.1	Quercus lyrata	Alluvial swamps	—	0	0.1
0.1	Planera aquatica	Alluvial swamps	—	—	0.2
0.1	Quercus laurifolia		—	0	0.1
0	Carpinus caroliniana	Bottoms, etc.	—	0.1	0

(and about 23 others)

SMALL TREES OR LARGE SHRUBS

.04	(Prunus angustifolia)	Old fields, etc.	0	.03	.05
.02	(Sassafras variifolium)	Old fields, etc.	0	.02	.02
.01	Persea pubescens	Non-alluvial swamps	—	.01	—

(and 5 others)

WOODY VINES

.005	Smilax laurifolia	Non-alluvial swamps	—	.01	0
.001	(Lonicera japonica)	Roadsides, etc.	—	0	0
.001	Tecoma radicans		0	0	0
0	Smilax Walteri	Swamps	—	0	0

(and about 8 others)

SHRUBS

.014	Arundinaria tecta	Low grounds	.02	.02	.01
.012	Myrica cerifera	Richer soils	.02	.01	.01
.011	Alnus rugosa	Swamps	.02	.01	.01
007	Clethra alnifolia	Damp sandy soils	.01	.01	.01
.007	Ilex glabra	Damp sandy soils	.01	.01	0
.006	Cyrilla racemiflora	Swamps	—	.01	—
.006	Phoradendron flavescens	On hardwood trees	.01	.01	.01
.006	Rhus copallina	Uplands	01.	.01	0
.004	Quercus pumila	Pine-barrens	—	0	.01
.003	Magnolia glauca*	Low pine-barrens	—	0	0
.002	Liquidambar Styraciflua	Low grounds	0	0	0
.001	Viburnum nudum	Branch-swamps, etc.	—	0	0
.001	Aralia spinosa	Richer soils	—	0	0
.001	Pieris nitida	Pocosins, etc.	—	0	0
.001	(Diospyros virginiana)		0	0	0
.001	(Rubus cuneifolius)	Roadsides, etc.	0	0	0
.001	Cephalanthus occidentalis	Swamps and ponds	—	0	0

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* See Bull. Torrey Club 34: 371–372. 1907.

.001	**Zenobia cassinifolia**	Pocosins, etc.	—	o	—
.001	Decodon verticillatus	Swamps	—	o	—
.001	**Baccharis halimifolia**	Low grounds	—	o	o
.001	**Myrica pumila**	Pine-barrens	—	o	o
o	**Hypericum fasciculatum**	Cypress ponds, etc.	—	o	o
o	**Ascyrum stans**	Damp sandy places	—	o	—
		(and about 25 others)			

HERBS

.005	Eupatorium rotundifolium	Low pine land	.001	.005	.005
.003	(Helenium tenuifolium)	Roadsides, etc.	o	.003	.003
.002	**Tillandsia usneoides**	On trees	—	.001	.005
.002	Sarracenia **flava**	Low pine-barrens	—	.003	.001
.002	Chondrophora **nudata**	Low pine-barrens	—	.003	.001
.002	(Leptilon canadense)	Fields and roadsides	o	.002	.001
.001	Pteridium aquilinum	Pine lands	.001	.001	.002
.001	Aristida **stricta***	Pine-barrens	—	.002	o
.001	Polygala lutea	Low pine-barrens	.001	.002	o
.001	Lespedeza capitata sericea	Pine lands	—	.001	.001
.001	(Syntherisma sanguinale)	Fields, etc.	o	.001	.001
.001	(Senecio tomentosus)	Roadsides, etc.	.006	.001	o
.001	Rhexia Alifanus	Low pine-barrens	—	.001	o
.001	**Chrysopsis graminifolia**	Uplands	.001	.001	.001
.001	Scirpus Eriophorum	Low grounds	o	.001	.001
.001	Habenaria ciliaris	Low pine land	o	.001	o
.001	(Euthamia caroliniana)	Roadsides, etc.	—	.001	o
.001	Osmunda cinnamomea	Low grounds	o	.001	.001
.001	Polygala ramosa	Low pine-barrens	o	.001	—
.001	(Ambrosia artemisiifolia)	Fields and roadsides	o	.001	.001
.001	Marshallia graminifolia	Low pine-barrens	—	.001	o
.001	Panicum hemitomon	Shallow ponds, etc.	—	o	.001
o	Campulosus aromaticus	Low pine-barrens	—	.001	o
o	Habenaria blephariglottis	Edges of swamps	—	.001	—
o	Erianthus sp.	Pine woods	—	.001	o
o	Eriocaulon **decangulare**	Low pine-barrens	—	.001	o
o	Anchistea virginica	Around ponds, etc.	—	.001	o
o	Afzelia cassioides	Pine lands	—	o	.001
o	Lilium Catesbaei	Low pine-barrens	—	.001	o
o	Polygala **cymosa**	Cypress ponds	—	o	.001
o	(Acanthospermum australe)	Roadsides, etc.	o	.001	o
o	Andropogon scoparius?	Uplands	o	o	.001
o	Eupatorium purpureum	Branch-swamps	o	o	o
o	Vernonia angustifolia	Dry pine-barrens	—	o	o
o	**Nymphaea sagittifolia**	Creeks and small rivers	—	.001	o
o	(Rhynchospora inexpansa)	Low grounds	.001	.001	—
o	Mesadenia lanceolata	Low pine-barrens	—	—	.001
o	Xyris sp.	Low pine lands	.001	o	o

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* See Bull. Torrey Club 37: 601–602. 1911.

o	(Stenophyllus floridanus)	Cultivated fields	—	—	.001
o	Oxypolis filiformis	Cypress ponds, etc.	—	o	o
o	Pontederia cordata	Cypress ponds, etc.	—	o	o
o	Typha latifolia	Marshes and ditches	o	o	o
o	(Diodia teres)	Roadsides, etc.	—	o	o
o	(Gnaphalium obtusifolium)	Old fields	—	o	.001
o	Eupatorium verbenaefolium	Low pine land	—	o	—
o	Andropogon sp.		—	o	o
o	Habenaria cristata?	Low pine land	—	o	o
o	(Agalinis fasciculata?)	Old fields	—	o	o
o	Solidago sp.		—	o	o
o	(Chaetochloa sp.)		—	o	o
o	Rhynchospora axillaris	Low pine-barrens	—	o	—
o	(Eupatorium capillifolium)		.001	o	o
o	(Lespedeza striata)	Roadsides, etc.	—	o	o
o	Ludwigia pilosa	Ponds, etc.	—	o	o
o	Andropogon glomeratus?	Low grounds	—	o	o
o	Ionactis linariifolius	Dry woods	—	o	o
o	Monarda punctata		—	o	—
o	Carphephorus bellidifolius?	Pine lands	—	o	—
o	Agalinis linifolia	Cypress ponds	—	o	o
o	(Eupatorium compositifolium)	Roadsides, etc.	—	o	o
o	(Sarothra gentianoides)	Old fields, etc.	—	o	o
o	Lycopodium alopecuroides	Low pine-barrens	—	o	—
o	Mikania scandens	Swamps	—	o	o
o	Laciniaria spicata?	Low pine-barrens	—	o	o
o	Zygadenus glaberrimus	Low pine-barrens	—	o	o
o	(Sida rhombifolia)	Roadsides, etc.	—	o	o
o	Mesosphaerum radiatum	Low pine-barrens	—	—	o
o	Iris versicolor	Low grounds	o	o	—
o	Helianthus angustifolius	Low pine land	—	o	—
o	(Chamaecrista fasciculata)	Old fields, etc.	—	o	o
o	(Polypremum procumbens)	Roadsides, etc.	—	o	o
o	Eriogonum tomentosum	Dry sand	—	—	o
o	Sabbatia lanceolata	Low pine-barrens	—	o	—
o	Dichromena latifolia	Low pine-barrens	—	o	o
o	Rhynchospora corniculata	Low grounds	o	o	o
o	Erianthus strictus	Low grounds	—	o	o
o	Juncus scirpoides	Low grounds	—	o	—
o	Cicuta Curtissii	Low grounds	o	o	—
o	(Cyperus rotundus)	Fields, etc.	—	o	o
o	Rhexia mariana?	Low grounds	o	o	—
o	Nymphaea fluviatilis?	River-swamps	—	o	o
o	Silphium compositum?	Dry pine land	o	o	o
o	Iris tripetala	Low grounds	—	o	—
o	Sarracenia purpurea	Pocosins, etc.	—	o	—

(and about 160 others)

Just how much a census taken at the time of the discovery of America would have differed from this it is impossible to say. It is very likely, however, that *Pinus Taeda* has replaced *P. palustris* to a considerable extent through the influence of civilization, as claimed by Ashe and others; one of the reasons for the change probably being the diminishing frequency of fire, for *P. Taeda* is more sensitive to fire than *P. palustris* is.

The percentages of evergreens are for Virginia 69.4, North Carolina 73.6, South Carolina 75.7, and for the whole region 74.0. The correspondence between these figures is close enough to give confidence in the method used, and at the same time the differences are just what one would expect from the slight differences in soil fertility in the three states already pointed out.*

So many of the Ericaceae and Leguminosae are not readily recognizable from a moving train that it is hardly worth while to attempt to give statistics for these plants for each state separately, but for the whole region the proportion of Clethraceae, Ericaceae and Vacciniaceae among the shrubs seems to be about 12 per cent. and of Leguminosae and allied families among the herbs about 4 per cent. The figure for Ericaceae is the same as that already obtained for northern Florida† while that for Leguminosae is lower. It is reasonably certain that the Ericaceae are most abundant in North Carolina and the Leguminosae in South Carolina.

By contrasting the more characteristic plants of each division we can get some interesting facts. In the following table the species which are most abundant in the Virginia portion are listed in the first column, the same for North Carolina in the second, and for South Carolina in the third. They are arranged in order of abundance, just as in the preceding table. Those starred seem to be at least twice as abundant in the state indicated as in either of the other two.

This table confirms in a general way observations of a similar nature made in passing through the same three states in 1906, but taking in a larger and more diversified area.‡ The proportion

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* Previous estimates of evergreen percentages for parts of the Carolina coastal plain (summarized in Bull. Torrey Club 41: 563–564. 1914) are now believed to be too low.

† Ann. Rep. Fla. Geol. Surv. 6: 395. 1914.

‡ Bull. Torrey Club 34: 363–366. 1907.

VIRGINIA	NORTH CAROLINA	SOUTH CAROLINA
	Trees	
Pinus Taeda	*Pinus serotina	*Pinus palustris
*Taxodium distichum	Nyssa biflora	Taxodium ascendens
Liquidambar Styraciflua	Acer rubrum	*Quercus Catesbaei
*Pinus echinata	*Gordonia Lasianthus	Quercus nigra
*Liriodendron Tulipifera		Fraxinus caroliniana
Cornus florida		Quercus Michauxii
*Nyssa uniflora		Hicoria alba?
*Quercus alba		Hicoria aquatica
Salix nigra		Quercus cinerea
Oxydendrum arboreum		Populus heterophylla
Betula nigra		*Planera aquatica
*Ilex opaca		*Quercus lyrata
Diospyros virginiana		Juniperus virginiana
*Platanus occidentalis		Quercus laurifolia
	Small trees	
	*Persea pubescens	Prunus angustifolia
	Vines	
	*Smilax laurifolia	Tecoma radicans
	Smilax Walteri	
	Shrubs	
Myrica cerifera	Ilex glabra	Phoradendron flavescens
*Alnus rugosa	*Cyrilla racemiflora	*Quercus pumila
Rhus copallina	Magnolia glauca	Diospyros virginiana
Liquidambar Styraciflua	*Viburnum nudum	Baccharis halimifolia
	Aralia spinosa	*Hypericum fasciculatum
	*Pieris nitida	
	*Zenobia cassinifolia	
	Decodon verticillatus	
	*Ascyrum stans	
	Herbs	
*Senecio tomentosus	*Sarracenia flava	Helenium tenuifolium
Eupatorium capillifolium	*Chondrophora nudata	*Tillandsia usneoides
	Leptilon canadense	*Pteridium aquilinum
	*Aristida stricta	*Chrysopsis graminifolia
	*Polygala lutea	*Scirpus Eriophorum
	Lespedeza capitata sericea	Osmunda cinnamomea
	*Rhexia Alifanus	Ambrosia artemisiifolia
	*Habenaria ciliaris	*Panicum hemitomon
	*Euthamia caroliniana	Afzelia cassioides
	*Polygala ramosa	Polygala cymosa
	*Marshallia graminifolia	Andropogon scoparius?
	*Campulosus aromaticus	Mesadenia lanceolata
	*Habenaria blephariglottis	Stenophyllus floridanus
	*Eriocaulon decangulare	Oxypolis filiformis
	*Anchistea virginica	Typha latifolia
	*Lilium Catesbaei	Diodia teres
	(and 24 others)	(and 12 others)

of trees is evidently highest in Virginia, and of shrubs and perhaps herbs in North Carolina.

Without taking up undue space by considering each species separately, it may be said that those in the Virginia list are mostly species that prefer soils richer in potash or humus than the average of the region.* Those in the North Carolina list are largely plants of moist pine-barrens or sandy or peaty bogs, called "bog xerophytes" by some American ecologists, and "oxylophytes" by Warming. Some of those in the South Carolina list may be restricted in their northward distribution by temperature, as suggested in 1907. Others are characteristic of cypress ponds, and some apparently prefer more ferruginous or phosphatic soils than the average of the region. (This may apply especially to the genus *Quercus*, of which there is one in the first column, none in the second, and seven in the third.) Some of the herbs are weeds, but just why weeds should be more abundant in South Carolina is not apparent. It is probably by such comparisons as these, preceded by careful analyses of environmental factors, that we can make the most progress in discovering just what is the optimum environment for each species.

Volumetric and dynamic studies. From reports of foresters on more or less similar areas (which need not be cited here), the stand of timber at the present time may be estimated roughly as 6,000 board feet of lumber per acre. This is equivalent to 500 cubic feet; but to make allowance for slabs, sawdust, tops, saplings, bushes, etc., the latter figure should be just about doubled, making 1,000 cubic feet of wood per acre.

The average increment of partly culled forests of *Pinus Taeda* is at least 3 per cent. annually, and as that is the most abundant species in the region under consideration we will not be far wrong if we take 3 per cent. for the annual increment of the whole vegetation, which would make 30 cubic feet of wood per acre per year.

The dry wood of *Pinus Taeda* weighs 34 pounds per cubic foot, according to Sargent, but that of most of the other trees is heavier, so that we will assume the average weight to be 37 pounds, and that of the woody increment 1,110 pounds per acre.

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* Several of the same species were found a few years ago to be more abundant in the pine-barrens of Mississippi than in those of Georgia; doubtless for similar reasons. See Bull. Torrey Club **41**: 563. 1914.

The percentage of ash in the wood is 0.26 in *Pinus Taeda*, but more in most of the other trees, say 0.32 on the average, which would make over three pounds of mineral matter taken each year from the soil by the wood alone. As the inorganic constituents of plants are chiefly concentrated in leaves and bark, and the herbs, which are renewed from the ground up every year, probably take as much from the soil per acre per year in such open forests as the trees do, we may safely multiply the last figure by forty or fifty, making something like 150 pounds per acre (equivalent to a layer of soil about 0.0005 inch deep) for the annual draft on the soil.

This is less than is taken from the soil by the average cultivated crop, even without fertilization, and it all goes back to the soil in the course of time, except what is removed by lumbermen and grazing animals or carried away by streams. Fire, though it destroys the humus and thus dissipates the nitrogen, at the same time accelerates the return of the mineral substances to the soil, and thus enables forests of the pine-barren type to do a large business on a small capital, so to speak. The gradual erosion of the whole surface, continually exposing deeper layers of soil, is probably sufficient to counteract the leaching and keep the soils from becoming steadily poorer.

The amount of water evaporated by average vegetation in moderately humid regions is said to be about 700 pounds to one pound of dry vegetable tissue, and if the total amount of vegetable matter produced in a year is four times the amount of new wood estimated above, or 4,440 pounds per acre, the water required for the region in question would be 3,108,000 pounds per acre, equivalent to about 16 inches of rain, or less than half as much as would evaporate from open water in that climate.*

The foregoing estimates are only crude approximations, but probably lie somewhere between half and double the correct figures; and when such a method is applied with skill and patience to the vegetation of different regions, or different habitats in the same region, it ought to yield some extremely significant results.

COLLEGE POINT, NEW YORK

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* See Transeau, Am. Nat. 39: 885; Rep. Mich. Acad. Sci. 7: 74. 1905.

INDEX TO AMERICAN BOTANICAL LITERATURE

1914-1916

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the word America being used in the broadest sense.

Reviews, and papers that relate exclusively to forestry, agriculture, horticulture, manufactured products of vegetable origin, or laboratory methods are not included, and no attempt is made to index the literature of bacteriology. An occasional exception is made in favor of some paper appearing in an American periodical which is devoted wholly to botany. Reprints are not mentioned unless they differ from the original in some important particular. If users of the Index will call the attention of the editor to errors or omissions, their kindness will be appreciated.

This Index is reprinted monthly on cards, and furnished in this form to subscribers at the rate of one cent for each card. Selections of cards are not permitted; each subscriber must take all cards published during the term of his subscription. Correspondence relating to the card issue should be addressed to the Treasurer of the Torrey Botanical Club.

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BULLETIN

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TORREY BOTANICAL CLUB

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Notes on Rosaceae—XI

PER AXEL RYDBERG

ROSES OF CALIFORNIA AND NEVADA

Two years ago I had practically completed the manuscript for the monograph of the genus *Rosa* to be printed in the North American Flora. As this would only make half a part as usually published, and as the rest of the manuscript for the same part, which is to be contributed by other persons, is not yet ready and may not be for some time, I thought it would be advisable to publish some of the notes and some of the descriptions of new species in advance. Besides, Professor Le Roy Abrams, of the Leland Stanford University, has sent me for determination the collection of North American roses, found in the herbarium of the said institution. I therefore think it is a proper time to put on record my present knowledge of the genus *Rosa*, with particular reference to California and Nevada, the two states best represented in that collection.

Key to the groups and species

- Pistils numerous; styles as well as the upper part of the hypanthium persistent.
  - Flowers corymbose or, when solitary, supported by bracts; achenes borne both on the inner walls and in the bottom of the receptacle; leaflets large.
    - Stem with scattered prickles, rarely also with intermixed bristles; sepals distinctly lobed; foliage glandular-punctate, sweet-scented. I. CANINAE.
    - Stem, at least the young shoots, bristly; prickles infrastipular or lacking; sepals entire or only the outer

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ones occasionally with one or two lobes; foliage not sweet-scented. II. Cinnamomiae.

- Flowers solitary, bractless; achenes inserted only in the bottom of the hypanthium; leaflets very small. III. Minutifoliae.

Pistils few; styles deciduous with the upper part of the hypanthium which falls off like a ring. IV. Gymnocarpae.

I. Caninae

A climbing rose. 1. *R. rubiginosa.*

II. Cinnamomiae

- Flowers mostly solitary; petals usually 2.5 cm. long or more; hypanthium in fruit 12–20 mm. thick; prickles straight.
  - Prickles stout, more or less flattened below, ascending; petioles, rachis, and lower surface of the leaflets not pilose, except sometimes on the veins.
    - Leaflets very thin, pale and slightly glandular-puberulent, but not muriculate beneath. 2. *R. nutkana.*
    - Leaflets thicker, dark-green on both sides, conspicuously glandular-muricate beneath. 3. *R. muriculata.*
  - Prickles weak, almost terete; petioles, rachis, and lower surface of the leaflets distinctly pilose. 4. *R. Brownii.*
- Flowers mostly corymbose; if solitary, the petals 2 cm. long or less; fruit rarely more than 1 cm. thick.
  - Prickles more or less curved; leaves more or less softly villous or pilose.
    - Leaflets not at all glandular beneath, mostly simple-toothed; hypanthium with a distinct neck, often ovoid. 5. *R. californica.*
    - Leaflets conspicuously glandular beneath, more or less double-toothed.
      - Hypanthium with a distinct neck.
        - Leaflets broadly oval or obovate; fruit subglobose or broadly obovoid. 6. *R. Aldersonii.*
        - Leaflets elliptic; fruit elongate-ellipsoid. 7. *R. Greenei.*
      - Hypanthium depressed-globose, without a neck; leaflets elliptic or narrowly oval. 8. *R. brachycarpa.*
  - Prickles straight or nearly so.
    - Hypanthium normally not bristly.
      - Hypanthium globose or nearly so; neck obsolete or inconspicuous.
        - Sepals lanceolate, with long caudate-attenuate or foliaceous tips, more than 1 cm. long.
          - Stipules, petioles, and rachis copiously glandular; leaflets orbicular or rounded-ovate, often double-toothed with gland-tipped teeth, more or less glandular-granuliferous beneath.
            - Leaflets very thin; prickles slender.

Leaflets green on both sides; petals about 2 cm. long. 9. *R. pinetorum.*
Leaflets pale beneath; petals about 1 cm. long. 10. *R. calavera.*
Leaflets not very thin, dark-green; prickles stout.
Leaves scarcely pubescent beneath. 3. *R. muriculata.*
Leaves decidedly pubescent beneath.
Leaflets rather simply serrate; hypanthium pilose when young. 11. *R. santae-crucis.*
Leaflets conspicuously double-serrate; hypanthium glabrous. 12. *R. Dudleyi.*
Stipules, petioles, and rachis not conspicuously glandular (stipules glandular-denticulate in no. 18).
Leaflets glabrous or nearly so.
Leaflets broadly oval, 3–5 cm. long. 13. *R. rivalis.*
Leaflets obovate to elliptic, rarely 3 cm. long.
Leaflets usually obovate, not shining; plant not conspicuously prickly. 14. *R. chrysocarpa.*
Leaflets elliptic, shining; plant usually very prickly. 15. *R. mohavensis.*
Leaflets more or less pubescent beneath.
Leaflets villous or pilose beneath, rounded or broadly oval; prickles stout.
Leaflets sparingly pubescent on both sides, thin; prickles rather few. 16. *R. myriantha.*
Leaflets pubescent on both sides, densely so beneath, thick; prickles very numerous. 17. *R. Davyi.*
Leaflets finely puberulent beneath; prickles rather weak.
Leaflets rounded-oval or suborbicular, thick; stipules conspicuously glandular-denticulate; petals less than 1 cm. long. 18. *R. rotundata.*
Leaflets elliptic to oval; stipules slightly if at all glandular-dentate; petals larger.
Sepals decidedly glandular on the back; prickles few, small and ascending. 19. *R. pisocarpa.*
Sepals not glandular on the back.

Leaflets broadly oval, thin, 2–5 cm. long; plant nearly unarmed. 20. *R. salictorum.*
Leaflets narrowly oval or elliptic, less than 3 cm. long.
Leaflets firm; prickles few. 21. *R. ultramontana.*
Leaflets thin; prickles numerous. 22. *R. gratissima.*
Sepals ovate, less than 1 cm. long, not conspicuously caudate; leaflets glandular-double-toothed, glabrous or slightly glandular-granuliferous beneath. 23. *R. Bolanderi.*
Hypanthium elongate, with a distinct neck.
Hypanthium glabrous.
Leaves finely puberulent beneath; fruit elliptic; plant unarmed or nearly so. 24. *R. Pринglei.*
Leaves glabrous; fruit urn-shaped; prickles rather stout, flattened below. 25. *R. Copelandii.*
Hypanthium pilose when young, ellipsoid; leaves pilose, densely so and glandular-granuliferous beneath. 26. *R. pilifera.*
Hypanthium densely bristly or prickly.
Leaflets thin, usually more than 1.5 cm. long, not glaucous; sepals more than 1 cm. long.
Leaflets densely glandular-granuliferous beneath; teeth usually lanceolate in outline. 27. *R. granulata.*
Leaflets sparingly glandular-granuliferous beneath; teeth ovate in outline. 28. *R. spithamaea.*
Leaflets firm, glaucous, less than 1.5 cm. long; sepals less than 1 cm. long. 29. *R. sonomensis.*

III. MINUTIFOLIAE

One species. 30. *R. minutiflora.*

IV. GYMNOCARPEAE

Leaves glabrous beneath; prickles very slender.
Flowers usually solitary, not leafy-bracted; stipules narrow; leaflets with lanceolate teeth; fruit 6 mm. in diameter or less.
Leaflets 5–7, usually more than 1.5 cm. long, the terminal one rounded at the base. 31. *R. gymnocarpa.*
Leaflets 7–9, usually less than 1.5 cm. long, the terminal one usually acute or cuneate at the base. 32. *R. prionota.*
Flowers mostly 2–4 together, leafy-bracted; upper stipules broadly dilated; leaflets with broadly ovate teeth; fruit 6–8 mm. broad. 33. *R. dasypoda.*
Leaves pubescent beneath; prickles usually stouter. 34. *R. Bridgesii.*

I. CANINAE. The members of this group are natives of the

Old World and are represented in this country by a few introduced species.

1. ROSA RUBIGINOSA L. Mant. 2: 564. 1771

The sweet brier is often cultivated and has escaped in many places in this country. In some parts of the eastern United States it is thoroughly naturalized. On the western coast it has established itself in several places in Oregon and Washington, but the writer has seen herbarium specimens only from one place in California. On account of its stout prickles it has been confused with *R. nutkana*, to which it has no close relationship.

CALIFORNIA: Yreka, 1910, *Geo. D. Butler 1427, 1802.*

II. CINNAMOMIAE. This group is represented in California and Nevada only by species of the true Cinnamomiae, i. e., species with infrastipular spines usually present.

2. ROSA NUTKANA Presl, Epim. Bot. 203. 1849

Although an easily distinguished species, except from the next two species, it has been mistaken for *R. fraxinifolia* Borkh. (i. e., *R. blanda* Ait.) and *R. Woodsii* Lindl. It has also been named *R. caryocarpa* Dougl. and *R. Lyalliana* Crépin, but these names have not been published except in synonymy. *R. aleutensis* Crepin is probably an unarmed form of this species. *R. nutkana* is distributed from Alaska to northern Wyoming and Oregon. It has also been reported from northern California, but the writer has no definite locality cited. Perhaps the record is based on specimens belonging to either of the next two species.

3. ROSA MURICULATA Greene, Leaflets 2: 263. 1912

This species is closely related to *R. nutkana* and perhaps not specifically distinct. It differs in the thicker and smaller leaves densely glandular-muricate beneath and in the often corymbose inflorescence. It ranges from British Columbia to northern California.

CALIFORNIA: Mad River, Humboldt County, 1878, *Violet Rattan;* Arcata, Humboldt County, 1899, *Dudley.*

4. **Rosa Brownii** Rydberg, sp. nov.

Stem slender, terete, glabrous, green or brownish, armed with slender straight prickles which are 5–8 mm. long, terete except the expanded depressed base; leaves five- to seven-foliolate; stipules ovate, acute; petiole and rachis finely pilose and more or less glandular; leaflets thin, 1–3 cm. long, serrate with some of the teeth double, broadly oval, acute at the apex, glabrate above, paler, pilose and slightly glandular-muricate beneath; flowers mostly solitary; pedicels 1–2 cm. long, glabrous; hypanthium globose, glabrous, in fruit about 12 mm. in diameter; sepals lanceolate, caudate-acuminate, usually with foliaceous tips, about 2 cm. long, glabrate on the back, tomentose and slightly glandular-hispid around the margins, and tomentose within; petals broadly obovate, rose-colored, 1.5–2 cm. long; styles distinct, persistent, not exserted; achenes inserted both on the inside and in the bottom of the hypanthium.

This species resembles somewhat *R. nutkana*, but the prickles are weak, not at all flattened, and the petioles, rachis and lower surface of the leaflets decidedly pilose. Much of the Californian material determined as *R. nutkana* belongs here.

CALIFORNIA: North side of Mt. Shasta, 1897, *H. E. Brown 349* (type, in the herbarium of the New York Botanical Garden); Humboldt Bay, 1901, *Chandler 1198;* Mendecino, 1903, *McMurphy 270.*

5. ROSA CALIFORNICA Cham. & Schlecht. Linnaea 2: 35. 1827

The original *R. californica* is characterized by its stout, flat, usually curved prickles, corymbose flowers, and its leaflets which are villous on both sides, usually simple-toothed and rarely slightly, if at all, glandular. The hypanthium is usually ovoid with a distinct neck. It is not uncommon throughout California, and two specimens have been seen from Lower California.

LOWER CALIFORNIA: San Ysidro Ranch, *Mearns 3865* (peculiar form); between Tio Juana River and Laguna, *Mearns 3504.*

6. ROSA ALDERSONII Greene, Pittonia 5: 110. 1903

This species differs from *R. californica* in the doubly serrate leaflets which are conspicuously glandular-granuliferous and only slightly, if at all, pubescent beneath. The first one to recognize it as different from the typical *R. californica* was C. A. Meyer, who called it *R. californica Petersiana*.* Crépin changed the varietal name to *glandulosa*.† He also gave *R. Aschersoniana* Crépin as a synonym. *Rosa Aldersonii* was described from a specimen, not quite of the usual form, having small, more rounded leaflets, short prickles and congested inflorescence. *Rosa Breweri* Greene‡ is, in my opinion, only a stunted and somewhat abnormal form of this species, with densely glandular pedicels and more hairy leaves. *R. Aldersonii* is, besides, very variable, usually with a subglobose hypanthium, with a distinct neck, but sometimes with a somewhat ellipsoid hypanthium. It also varies in having larger or smaller leaflets and with numerous or few flowers. Sometimes the styles are more or less exserted. It is fully as common as the preceding throughout California.

7. **Rosa Greenei** Rydberg, sp. nov.

Stem rather slender, 1 m. or so high, purplish, glabrous, armed with curved infrastipular prickles, which are more or less flattened, 3–6 mm. long; leaves five- to seven-foliolate; stipules narrow, 1–1.5 cm. long, densely glandular-puberulent; petiole and rachis glandular-puberulent and somewhat prickly; leaflets elliptic, acute at both ends, 2–4 cm. long, glandular-double-toothed, puberulent above, glandular-puberulent and slightly pilose beneath; inflorescence corymbiform or paniculate; pedicels 1–2 cm. long, glandular-puberulent; hypanthium elongate-ellipsoid, with a distinct neck, in fruit 2 cm. long and 1 cm. in diameter; sepals lanceolate, caudate-acuminate, about 2 cm. long, glandular-hispid on the back, tomentose within, in fruit persistent and erect; petals about 15 mm. long, rose-colored; styles distinct, persistent, not exserted.

This is related to *R. Aldersonii*, but differs in the narrower leaflets and the decidedly ellipsoid hypanthium, with a long neck.

CALIFORNIA: Santa Cruz Island, July and August, 1886, *E. L. Greene* (type, in the United States National Herbarium); apparently also San Mateo, *Heller 8582*.

8. **Rosa brachycarpa** Rydberg, sp. nov.

Stem apparently tall, stout, purple, armed with curved flattened infrastipular prickles, which are about 5 mm. long; leaves mostly seven-foliolate; stipules not strongly dilated, 1–1.5 cm. long, glandular-ciliate on the margins and glandular-puberulent on the back; petioles and rachis glandular-puberulent and slightly prickly; leaflets elliptic or narrowly oval, mostly acute at both ends, rather evenly serrate, with broad, occasionally double, and gland-tipped teeth, conspicuously glandular-puberulent and slightly pilose beneath, 2–4 cm. long; inflorescence rather many-flowered, corymbiform; pedicels about 1 cm. long, glabrous or nearly so; hypanthium depressed-globose, without a neck; sepals ovate, caudate-acuminate, about 1.5 cm. long, glabrous on the back, villous on the margins and tomentose within; in fruit erect and persistent; petals about 15 mm. long; styles distinct, persistent, decidedly exserted.

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* Linn. 19. 1848.

† Bull. Soc. Bot. Belg. 15: 52. 1876.

‡ Leaflets 2: 262. 1912.

This species is also related to *R. Aldersonii*, but differs from all the other relatives of *R. californica* in the hypanthium lacking the neck, and in the decidedly exserted styles.

CALIFORNIA: Temescal Cañon, near Elsinore, May 23, 1892, *McClatchie* (type, in the herbarium of the New York Botanical Garden).

9. ROSA PINETORUM Heller, Muhlenbergia 1: 53. 1904

This species has been collected only in the neighborhood of the type station, that is around Monterey Bay. The following specimens have been seen.

CALIFORNIA: Pacific Grove, *Heller 6817;* 1907, *Patterson & Wiltz;* 1908, *L. E. Cox;* Point Piños, *Heller 8413;* Monterey, *Parry*.

10. ROSA CALAVERA Greene, Leaflets 2: 257. 1912

This was included in the *R. gymnocarpa* group by Dr. Greene, perhaps on account of the shape of the leaflets and the small flowers, but the sepals and style are persistent and it is more nearly related to *R. pinetorum*, differing in the small flowers and the leaflets which are pale beneath. While *R. pinetorum* is confined to the coast, this species belongs to the Sierra Nevada.

CALIFORNIA: Calveras Big Tree Grove, *E. L. Greene;* Tulare County, *Dudley*, at the following localities: Second Dry Meadow Creek, Kern River, 1895; Board Camp, 1902; Keweath River Valley, 1896, *1385*, *1367*, *1313a;* Redwood Meadow, Alta Peak, 1896, *1642;* Coffee Pot Camp, 1897, *1765;* Hollow Log Camp, 1900; east of Sequoia Grove.

11. **Rosa santae-crucis** Rydberg, sp. nov.

Stem 1–2 m. high, dark reddish-brown, glabrous, armed with straight stout infrastipular prickles about 1 cm. long and more or less flattened; leaves mostly five-foliolate; stipules 1.5–2 cm. long, pubescent as well as densely glandular-muricate, more or less lobed; free portion ovate, obtuse; petiole and rachis villous and glandular-puberulent; leaflets rounded-oval, 1–3 cm. long, rounded at each end, rather simply serrate, with broad ovate teeth, pilose and glandular-puberulent above, villous and conspicuously glandular-muriculate beneath; inflorescence corymbose, many-flowered, leafy-bracted; pedicels short; hypanthium globose, pilose when young, in fruit 12–15 mm. in diameter; sepals lanceolate, caudate-attenuate, 15–20 mm. long, villous and glandular-hispid, erect and persistent in fruit; styles included, distinct, persistent; achenes inserted both in the bottom and on the inside of the hypanthium.

This species suggests closely *R. Aldersonii* and its relatives, but the prickles are straight.

CALIFORNIA: island of Santa Cruz, 1886, *E. L. Greene* (in the Greene herbarium).

12. **Rosa Dudleyi** Rydberg, sp. nov.

A low shrub 3–5 dm. high; branches reddish or greenish, armed with infrastipular straight prickles 5–10 mm. long, somewhat flattened below, and with smaller scattered prickles on the new shoots; leaves usually five- to seven-foliolate; stipules narrow, glandular-puberulent and conspicuously glandular-dentate; free portion lanceolate; leaflets rounded-oval, or the terminal one rounded-obovate, 1–2 cm. long, conspicuously double-serrate with gland-tipped teeth, pubescent on both sides and glandular-puberulent and somewhat paler beneath; flower corymbose; hypanthium glabrous, subglobose, in fruit about 1 cm. broad; sepals densely puberulent on both sides, grayish within, glandular-ciliolate, in age 12–15 mm. long, caudate-acuminate; petals about 1 cm. long.

In general appearance it resembles somewhat *R. sonomensis* and *R. Bridgesii*, but differs from the former in the glabrous, not bristly, hypanthium and from the latter in the persistent styles and sepals, the stouter spines, and larger subglobose fruit. It is most closely related to *R. calavera*, but differs in the thicker, more hairy leaves and stouter prickles.

CALIFORNIA: near Booles Home, Converse Basin, Fresno

County, October 16, 1900, *Dudley 3388* (in the Dudley herbarium, Leland Stanford University).

13. ROSA RIVALIS Eastw. Bull. Torrey Club 32: 198. 1905

This species is related to *R. Woodsii* and *R. pisocarpa*, but its leaflets are much larger, broader and thinner, broadly oval, sometimes almost orbicular and perfectly glabrous beneath. They resemble somewhat those of *R. myriantha*, which, however, has pubescent leaves. I have not seen the type of this species but showed Kellogg & Harford's No. 226 to Miss Eastwood, and she said that she regarded the same as typical *R. rivalis*. In the Missouri Botanical Garden herbarium, the locality of this number is given as San Francisco. This is probably wrong. In the herbarium of the New York Botanical Garden, Kellogg's field label is present, which reads: "Rosa. Long Valley, June 11, 1869, red, 7 or 8 feet high—along shady rivulet—Kellogg." According to Miss Eastwood, Long Valley is not very far from the type locality of *R. rivalis*. A form with leaves somewhat pubescent beneath and somewhat glandular petioles was collected by Mrs. Austin (No. 400) at Mill Creek, California. The following belong to *R. rivalis:*

CALIFORNIA: Long Valley, *Kellogg & Harford 226;* Placer County, 1893, *Mrs. Hardy* (on this sheet Crépin has written: "N'est pas le *R. spithamaea* Wats., ou le *californica*, etc.").

OREGON: Cold Spring, Crook County, 1898, *Coville & Applegate 131*.

14. **Rosa chrysocarpa** Rydberg, sp. nov.

Stem tall, 1–3 m. high, terete, at first light yellowish green, later grayish brown, armed with straight prickles, somewhat retrorse, terete, 3–7 mm. long, usually more or less flattened at the very base, some of them infrastipular, others scattered, of various lengths; young shoots copiously armed with bristle-like prickles; floral branches 1–2 dm. long, armed with mostly infrastipular prickles; stipules adnate, glabrous, 1–2 cm. long, the lower narrow, the upper dilated, glandular-dentate or ciliate on the margins; petiole and rachis glabrous, sometimes with a few prickles; leaflets five to seven, elliptic or oval, thin, glabrous on both sides, yellowish green, coarsely serrate throughout, petioluled, 1–4 cm. long; flowers corymbose, leafy-bracted; pedicels 1–2 cm. long, glabrous; hypanthium globose, glabrous, at first light-green, in fruit about 1 cm.

thick and orange; sepals lanceolate, caudate-attenuate, about 1.5 cm. long, glabrous or nearly so on the back, tomentose on the margins and within, in fruit erect and persistent; styles distinct, persistent, not exserted; achenes inserted both in the bottom and on the inside of the hypanthium.

This species is related to *R. Woodsii*, but differs in the yellowish green leaflets, sharply serrate with teeth directed forward, the orange fruit and usually many-flowered corymbs. The following belong here:

UTAH: Allen Cañon, 1911, *Rydberg & Garrett 9302* (type, in the herbarium of the New York Botanical Garden); Logan, *Miss Mulford 189*.

IDAHO: Castford, 1912, *Nelson & Macbride 1749;* Rock Creek, 1911, *Macbride 1375;* King Hill, 1912, *Nelson & Macbride 1109*.

NEVADA: Franktown, *Kennedy 1935;* Kings Cañon, *Baker 1221*.

CALIFORNIA: Dutch Flat, Placer County, 1909, *Dudley*.

15. ROSA MOHAVENSIS Parish, Bull. So. Calif. Acad. 1: 87. 1902

This was originally described as *R. californica glabrata* Parish. Parish overlooked the fact that there was an older *R. californica glabrata* Crépin. The present species is not related to *R. californica* but to *R. Woodsii*, from which it differs in the shining, elliptic instead of obovate, leaflets.

CALIFORNIA: Cushenberry Spring, *Parish 4941;* Aqueduct, Amador County, *Hansen 1813*, in part; Southern California, *Elmer 3732; Abrams 2821*.

16. ROSA MYRIANTHA Carr. Rev. Hort. 1865: 448. 1865

This species, not uncommon in California, has generally been overlooked. Crépin, apparently not knowing it very well, admitted it as a variety *glabra* of *R. californica*, notwithstanding the fact that it has straight prickles. Regel described it under the name *R. californica*. From his treatment it is not evident that he even knew of the existence of *R. californica* Cham. & Schlecht., but it is evident that he was not familiar with it. The following specimens belong to *R. myriantha:*

CALIFORNIA: Eel River, *Heller 6014;* Red Reef Cañon, *Abrams & MacGregor 135;* Goose Lake, *Mrs. Austin 455;* "California," *Kuntze 3205;* Berry Cañon, *Heller & Brown 5546;* Butte County, *Mrs. Austin 1800; Colby 752;* Sonoma County, *Heller 5678;* Little Chico, *Mrs. Austin 1807;* Round Valley, *Chestnut 212;* San Diego County, *Abrams 3763;* Laguna, *Mearns 36050; Schoenfeldt 3598;* Dulzura & El Mido, *Mearns 3879;* Witch Creek, San Diego County, *Abrams 4914.*

OREGON: Barlow Gate, *Lloyd;* Lower Albina, Portland, *Sheldon 10659;* Wimmer, *Hammond 119,* in part.

17. **Rosa Davyi** Rydberg, sp. nov.

Stem stout, 5–10 m. long, glabrous, armed with numerous stout prickles flattened below; leaves five- to seven-foliolate; stipules broad, 1–1.5 cm. long, glandular-dentate on the margin, densely villous, free portion lanceolate to ovate; rachis and petiole villous and sometimes glandular-hispid, usually with a few prickles; leaflets broadly oval, 1–2.5 cm. long, rather firm, rounded at both ends, coarsely and simply serrate, short-pilose above, villous beneath; flowers two or three together or solitary; pedicels 1–2 cm. long; hypanthium globose, glabrous, in fruit 15 mm. in diameter, purple; sepals lanceolate, caudate-acuminate, 15 mm. long or more, villous on the back, tomentose within, erect and persistent in fruit; petals about 2 cm. long, obcordate; styles persistent, distinct, not exserted.

Rosa Davyi resembles *R. californica* in the leaf-form, but the prickles are long, straight and very numerous. It is a rare species. Greene collected a specimen without flower or fruit, which was nearly 7 m. high, at San Joaquin. The prickles are straight, flat, and nearly 1 cm. long. It evidently belongs here.

CALIFORNIA: Saratoga, *Davy 263* (type, in the herbarium of Columbia University); Mendocino, *McMurphy 270.*

18. **Rosa rotundata** Rydberg, sp. nov.

A stout shrub, more than 5 dm. high; new canes copiously armed with slender, straight, almost terete prickles, 5–10 mm. long; branches red or purplish, with smaller infrastipular and scattered prickles; leaves mostly five- to seven-foliolate; stipules large, lance-ovate, puberulent on both sides, conspicuously glandular-denticulate, 1–1.5 cm. long; leaflets rounded, oval or suborbicular, 1–1.5 cm. long and nearly as broad, finely puberulent on both sides, coarsely crenate-serrate with broad teeth; flowers corymbose; hypanthium round-ellipsoid or globose, with a short neck; sepals ovate, caudate-acuminate, about 8 mm. long, villous within and on the margins; petals 8–10 mm. long.

This species is related to *R. pisocarpa* and *R. ultramontana*, but differs in the shorter and broader thicker leaflets, the more prominent armature, and the small flowers.

NEVADA: mountains west of Franktown, 1912, *Heller 10520* (type, in the herbarium of the New York Botanical Garden).

19. ROSA PISOCARPA A. Gray, Proc. Am. Acad. 8: 382. 1872

Professor Crépin badly misunderstood this species. Nearly anything with a small hypanthium he referred to it. Specimens of *R. Woodsii*, *R. Fendleri*, *R. ultramontana*, together with two undescribed species, and even *R. Engelmanni* we find determined as *R. pisocarpa* by him. It belongs purely to the Columbia Valley region and is not found in the Rocky Mountain states. It is characterized by the elliptic or oval leaflets, finely puberulent beneath, the comparatively short and glandular sepals, the numerous flowers and short ascending straight prickles.

The only specimen from California seen by the writer is one collected by Mrs. Austin without definite locality.

20. **Rosa salictorum** Rydberg, sp. nov.

Stem slender, 3–5 m. high or in open places lower, unarmed or nearly so, except the new shoots, which are bristly at the base; infra-stipular spines seldom present; leaves five- to seven-foliolate; stipules adnate to the petioles, 1.5–2 cm. long, the upper dilated, more or less toothed, finely puberulent; petioles and rachis unarmed, puberulent; leaflets broadly oval, coarsely and evenly serrate, thin, equally green on both sides, glabrous above, finely puberulent beneath, rounded or acute at both ends, 2–4 cm. long; flowers corymbose, conspicuously leaf-bracted; pedicels glabrous; hypanthium glabrous, globose, contracted above, in fruit about 1 cm. broad; sepals lanceolate, caudate-acuminate, about 15 mm. long, glabrous on the back, tomentose within and on the margins, erect and persistent in fruit; petals pink, about 15 mm. long; styles distinct, persistent, not exserted.

This species is related to *R. pisocarpa* and *R. ultramontana*, but differs from both in the large, thin, broadly oval leaflets and the few slender prickles. It is almost unarmed except on the new shoots. From *R. pisocarpa* it also differs in the non-glandular sepals.

NEVADA: Gold Creek, July 25, 1912, *Nelson & Macbride 2113* (type, in the herbarium of the New York Botanical Garden), also *2113;* McDonalds Creek, *2156;* Owyhee River, *2196;* Big Creek, Lander County, *Kennedy 4106, 4544;* Martin Creek, 1913, *4491;* Star Canyon, southeast of Death, *Heller 10570.*

21. ROSA ULTRAMONTANA (S. Wats.) Heller, Muhlenbergia 1: 107. 1904

This was first described as *R. californica ultramontana* S. Wats.,* but is not at all related to that species. It is closely related to *R. pisocarpa* and distinguished from that mainly by the sepals which are not at all glandular. It belongs to the Great Basin, is rather common in Nevada as well as Idaho and eastern Oregon, but not so common in California. The following specimens have been seen.

CALIFORNIA: Little Grizzly Creek below Genessee, Plumas County, 1907, *Heller & Kennedy;* Hornbrook, 1909, *Rusby;* Lake Tahoe, 1909, *Dudley;* Hot Springs, Sierra Valley, 1909, *Dudley;* El Dorado County, 1900, *Dudley.*

22. ROSA GRATISSIMA Greene, Fl. Franc. 73. 1891

To this belong the following specimens:

CALIFORNIA: Griffins, *Elmer 3732;* South Fork of Kings River, 1899, *Eastwood;* Bear Valley, *Abrams 2821;* Water Cañon, *Abrams & MacGregor 482;* Sky Valley, *Culbertson 4873;* Long Pine, 1897, *M. E. Jones;* Bear Valley, *Hall 1324* (?); Colby, *Mrs. Austin* (?); South Fork of Santa Anna, *Grinnell 232;* San Bernardino Mountains, *Parish 3274;* North Fork of Kern River, *V. Bailey 1720;* Big Arroya, Soda Springs Trail, Tulare County, *Dudley 2307;* Glenbrook, near Lake Tahoe, 1906, *Dudley;* Lockwood Creek, Mount Pinos Region, *Dudley & Lamb 4634.*

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* Bot. Calif. 1: 187. 1876.

23. ROSA BOLANDERI Greene, Leaflets 2: 261. 1912

This species is related to the *R. Covillei* of Oregon, but the leaflets are thinner, glandular, double-toothed and decidedly glandular-pruinose beneath. Crepin determined the type as *R. gymnocarpa* with the remark that the sepals were persistent. Dr. Greene also classified it in the *Gymnocarpae*, but it evidently does not belong there.

CALIFORNIA: Oakland, *Bolander*.

24. **Rosa Pringlei** Rydberg, sp. nov.

Stem dark gray, 1 m. high or more, terete, slender, sparingly armed with small straight infrastipular prickles, 3–5 mm. long, or wholly unarmed; branches 1–3 dm. long, usually unarmed; stipules adnate, rather narrow, 1 cm. long or less, densely and finely puberulent on the back; the free portions lanceolate, ascending, spreading, slightly glandular-ciliate; petiole and rachis densely puberulent, not at all glandular; leaflets five or seven, elliptic, 2–3 cm. long, acutish at both ends, rather firm, finely puberulent on both sides, densely so, almost velvety, and paler beneath; flowers corymbose, two to five together; pedicels 1–2 cm. long, glabrous; hypanthium ellipsoid, acute at the base, above produced into a distinct neck, glabrous, in fruit 9–10 mm. thick, 12–14 mm. long, dark-purple; sepals lanceolate, caudate-attenuate, 12–15 mm. long, finely puberulent, in fruit erect and persistent; achenes inserted both in the bottom and on the insides of the hypanthium.

This is related to *R. pisocarpa*, *R. ultramontana* and *R. Macounii*. The leaves are dark green above, finely toothed with rather blunt teeth and the hypanthium is decidedly ellipsoid, with a neck. The plant is almost unarmed. The type in the Columbia University herbarium has no prickles, but the same number in the United States National Herbarium has a single straight prickle about 5 mm. long. This was determined as *R. pisocarpa* by Crépin. Suksdorf's specimen is unarmed and Sheldon's has only a few prickles.

CALIFORNIA: Siskiyou County, 1882, *Pringle* (type, in the herbarium, Columbia University); 1910, *G. D. Butler 1352;* Vicinity of Rawhide, 1905, *Roxana Stinchfield 25*, in part; near Stirling, 1913, *Heller 10801*.

WASHINGTON: Klickitat County, 1885, *Suksdorf*.

OREGON: Wallowa River, 1897, *Sheldon 8087*(?).

25. **Rosa Copelandii** Greene, sp. nov.

Stem dark purple, terete, shining, sparingly armed with straight infrastipular prickles, which are about 5 mm. long, rather stout and somewhat flattened below; floral branches 1–2 dm. long, purple, more or less armed; stipules 1–2 cm. long, adnate, glabrous, more or less dilated, thin, often tinged with purple; free portion semi-lunate, acuminate; petiole and rachis glabrous, often slightly prickly, purplish; leaflets five or seven, oval or elliptic, thin, perfectly glabrous on both sides, finely serrate, 1–3 cm. long; flowers corymbose; pedicels glabrous, short, 1–1.5 cm. long; hypanthium glabrous, urn-shaped, rounded at the base, prolonged above into a distinct neck, in fruit 9–10 mm. thick, 10–12 mm. long; sepals lanceolate, about 15 mm. long, caudate-attenuate, glabrous on the back, tomentose on the margins, in fruit erect and persistent; achenes inserted in and near the bottom of the hypanthium.

Dr. Greene recognized this species, but for some reason did not publish it. It is characterized by its ovoid urn-shaped hypanthium, with a conspicuous neck, and glabrous leaves.

CALIFORNIA: Mt. Eddy, Siskiyou County, September 8, 1903, *Copeland* [Baker's distribution number] *3875*.

26. **Rosa pilifera** Rydberg, sp. nov.

Stem 1 m. high or more, at first yellowish, in age dark gray, terete, armed with straight infrastipular and scattered prickles 3–5 mm. long, somewhat flattened below; floral branches 1–3 dm. long, usually sparingly armed; stipules adnate, the lower narrow, the upper dilated, 1–1.5 cm. long, pilose and glandular on the back, glandular-ciliolate on the margins; free portion linear-lanceolate to ovate, ascending; petiole and rachis pilose, glandular and sometimes with a few weak prickles; leaflets five to seven, thin, oval, 2–3.5 cm long, sparingly pilose above, more densely so and somewhat glandular-pruinose beneath, usually more or less double-toothed and the teeth often gland-tipped; flowers corymbose; pedicels 1–3 cm. long, more or less pilose; hypanthium ellipsoid, with a neck, pilose at least when young, in fruit 8–10 mm. thick, 12–15 mm. long; sepals lanceolate, caudate-attenuate, 1.5 cm. long, more or less pilose, in fruit erect; petals about 1.5 cm. long; styles distinct, persistent, not exserted.

This species has the leaflets of *R. Aldersonii*, i. e., double-toothed and glandular beneath, but they are thinner, the prickles are slender, straight, or rarely slightly curved, and the young hypanthium at least is covered with fine soft hairs. The following belong here:

CALIFORNIA: San Francisco, *Dr. Bolander* (type, in the herbarium of Columbia University); Berkeley, *Burt Davy 854;* Pine Grove, Amado County, *George Hanson 7310;* no locality, *Kellogg & Harford 225* in part; Sierra National Forest, 1912, *Abrams 4969.*

27. ROSA GRANULATA Greene, Leaflets 2: 262. 1912

This is closely related to *R. spithamaea,* but differs in the more glandular leaves and narrow teeth. Perhaps not specifically distinct. It is known only from the type collection at San Luis Obispo.

28. ROSA SPITHAMAEA S. Wats. Bot. Calif. 2: 444. 1880

This is a rather local species characterized by its almost herbaceous stems, slender prickles and bristly receptacle.

Hoopa

CALIFORNIA: Trinity River, between Hyamp~~ore~~um and Hooper, 1878–1883, *Rattan;* Trinity Mountains, *Marshall;* Lake County, 1902, *Heller;* "California," *Torrey.*

OREGON: Wimmer, *Hammond 120.*

29. ROSA SONOMENSIS Greene, Fl. Franc. 72. 1897

This is related to *R. spithamaea,* but differs from the other Californian species with prickly fruit in the firm glaucous leaves, the densely prickly stem, and the short sepals.

CALIFORNIA: Petrified Forest, Sonoma County, 1883, *Greene;* Mount Tamalpais, *V. Bailey 531;* 1885, *Rattan;* Converse Basin, Fresno County, 1904, *Dudley.*

III. MINUTIFOLIAE. This group is represented by the following species and by two species in New Mexico.

30. ROSA MINUTIFOLIA Engelm. in Parry, Bull. Torrey Club 9: 97. 1882

This species is a native of Lower California and may be expected in San Diego County, California.

LOWER CALIFORNIA: Todo Santos Bay, *Parry*, *Pringle*, *Orcutt*; Ensenada, *M. E. Jones 3697*, *Anthony 189*; San Quentin Bay, *Palmer 619*.

IV. GYMNOCARPAE. This is a little group of species all confined to the North American Pacific coast.

31. ROSA GYMNOCARPA Nutt.; Torrey & Gray, Fl. N. Am. 1: 461. 1840

Until recently only one species, *Rosa gymnocarpa* Nutt., and one variety, var. *pubescens* S. Wats., have been admitted to this group. *R. gymnocarpa* ranges from British Columbia to Montana, Idaho and California. Dr. Greene in one paper* described not less than twelve species which he regarded as belonging to this group and seven more related to it but "not at all gymnocarpous." It is impossible for me to follow him in his segregation of *Rosa gymnocarpa*, and several of his "gymnocarpous" species do not belong to the group at all.

The Greenian species really belonging to the *Gymnocarpae* are the following: *R. glaucidermis*, *R. crenulata*, *R. prionata*, *R. piscatoria*, *R. abietorum*, *R. amplifolia*, *R. leucopsis*, *R. Helleri*, *R. apiculata*, and *R. dasypoda*. Of these the only clearly distinct species is *R. crenulata*, which, however, has an older name, *R. Bridgesii* Crépin. Of the others I have retained as tentative species *R. prionata*, *R. leucopsis* and *R. dasypoda*, but none of these are too good as species. They are fairly good varieties, but the rest are hardly worth naming even as forms. As most of them belong to the Columbia Valley region, I shall discuss them further in a subsequent paper and only mention those found in California.

32. ROSA PRIONOTA Greene, Leaflets 2: 256. 1912

The species is distinguished from *R. gymnocarpa* by the small and often more numerous (seven to nine instead of five to seven) leaflets with narrower and sharper teeth. The terminal leaflet is usually cuneate at the base instead of rounded. The fruit is described as globose. Both in this species and in *R. gymnocarpa* the immature hypanthium is ellipsoid. If only one to three achenes are developed, it remains so even at maturity, but if more achenes develop the fruit becomes pear-shaped or globose. The form of the fruit is, therefore, no specific character. *R. apiculata* Greene and *R. piscatoria* are forms of this species. The former will be discussed in a subsequent paper. The latter represents a strong more bristly form of *R. prionota.*

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* Leaflets 2: 254–261. 1912.

Rosa prionota is more common in California than the typical *R. gymnocarpa.*

33. ROSA DASYPODA Greene, Leaflets 2: 260. 1912

This is perhaps a good species. I had segregated out the same as such, although I had assigned as the type a Californian specimen which shows the characters better than Dr. Greene's type. The flowers are nearly always corymbose, i. e., two to four together and leafy-bracted, the leaflets thicker and not with semi-pellucid veins, the teeth broader and more rounded, and the fruit is larger, 6-8 mm. instead of 4-6 mm. in diameter.

It ranges from British Columbia to northern California, where it is represented by the following specimens:

CALIFORNIA: Siskiyou County, *Copeland* [Baker's distribution number] *3874*.

34. ROSA BRIDGESII Crépin, Bull. Soc. Bot. Belg. 15: 54. 1876

This is a good species and is the same as *R. gymnocarpa pubescens* S. Wats.* and *R. crenulata* Greene.† Crépin gave this species a short description, but later, after seeing Watson's treatment of the same, retracted and reduced it to a variety. I was a little doubtful whether the name *R. Bridgesii* belonged to this species or to *R. sonomensis* or to some related species, but Miss Eastwood, who has seen the type of *R. Bridgesii*, has told me that it is the same as *R. gymnocarpa pubescens* S. Wats. The following specimens have been seen from California:

CALIFORNIA: *Bridges 95;* Pine Ridge, Fresno County, *Chandler 171; Baker 5500;* Silver Mountain Pass, *Brewer 1915;* Havelock, Kern County, *Grinnell 217;* Tuolumne Big Trees, 1911, *Abrams 4701;* Shut Eye Pass, 1912, *4928;* Yosemite Park, 1915, *5407*.

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* Bot. Calif. 1: 187. 1876.

† Leaflets 2: 255. 1912.

There are, in the collections examined, a few specimens from Nevada and the Klamath region of California which can not be referred to any of the species treated above. Some of these may be referred to *R. Macounii*, but the localities are out of the known range of that species. The rest may belong to two or three apparently undescribed species from the Columbia Valley and the Great Basin, but the limitations of these species are still unsettled.

NEW YORK BOTANICAL GARDEN

On the cause of alternate bearing in the apple

O. BUTLER

(WITH PLATES 1–3 AND A TEXT FIGURE)

I

The production of a heavy crop of fruit every other year, or alternate bearing, is a well-marked phenomenon in the apple and pear, and is not unknown in certain plums and cherries. Alternate bearing in the apple, however, has been more particularly recorded by American horticultural writers, who have proposed a variety of ways of obviating this vexatious propensity.

Thacher[*] remarks that trees that are allowed to stand unpruned bear only every other or third year, and his remedy for irregular bearing is the knife.

Downing[†] states that the apple bears in alternate years, but that when the fruit is thinned a tree will bear every year "as it will also if the soil is kept in high condition."

Cole[‡] observed that apple trees are inclined to bear in the even numbered years (1846, '48, '50) and lightly in the odd years (1845, '47, '49) and expresses the view that removing the blossoms will change the bearing year.

Fitz[§] recognizes alternation of bearing in the apple and states that the most profitable way to obtain annual crops is by proper tillage and proper fertilization.

Thomas[†] believes that thinning the fruit while the applies are small will induce regular bearing and that picking off all the fruit in the fruitful year will change the year of crop abundance.

Maynard[¶] states that in most apple orchards large crops of fruit are only produced biennially and that in the northern fruit sections the productive year has become more or less fixed on the even year. Alternation of bearing may be brought about by overproductiveness resulting in an exhaustion of the tree which then requires one or more years to develop flower buds again, or it may be due to climatic agencies.

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[*] **Thacher, J.** The American Orchardist, Ed. 2, 69. Plymouth, Mass. 1825.

[†] **Downing, A. J.** The fruits and fruit trees of America, 61. New York and London. 1845.

[‡] **Cole, S. W.** The American fruit book, 87. Boston. 1850.

[§] **Fitz, James.** The southern apple and peach culturist, 118. Richmond. 1872.

[‖] **Thomas, J. J.** The American fruit culturist, Ed. 20, 243. New York. 1897.

[¶] **Maynard, S. T.** Successful fruit culture, 44. New York. 1905.

According to Maynard the bearing year may be changed: 1st, by removing part or all the fruit; 2d, by manuring the orchard during the productive year with bonemeal and potash, or bonemeal and wood ashes, or by using nitrate of soda or stable manure in the unproductive year; 3d, by seeding the orchard to grass during the bearing year; 4th, by ploughing the land in the unfruitful year and cultivating during the productive year; 5th, by canker worms or vernal frosts destroying the blossoms.

Powell* observes that the alternate bearing habit once acquired will in all probability be kept up indefinitely. Alternate bearing is brought about by unfavorable climatical conditions, such as hibernal cold or damp weather at blossoming time.

Waugh† notes that alternate bearing is particularly marked in the Baldwin apple and believes that more regular productiveness could be obtained by thinning the fruit.

What is the cause of biennial bearing in the apple and what is the *raison d'être* of the methods proposed to equalize fruitfulness?

II

The biennial bearing of apple trees was credited to its proper cause by Jules Courtois in a lecture before the Horticultural Society of Seine-et-Oise. Hardy‡ quotes at length from the report of this lecture, and from this quotation I translate the following passages bearing on the question of the alternation of bearing in the apple:

> Again one often sees in pear and apple trees flower buds forming like *bouquets de mai*§ of the stone fruits the second year and expanding the third.
>
> There is even a kind of an eye‖, the eyes of the purse (*bourse*), of which this is

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* Powell, E. P. The orchard and fruit garden, 14. New York. 1905.

† Waugh, F. A. The American apple orchard. New York. 1912.

‡ Hardy, J.-A. & A.-F. Traité de la taille des arbres fruitiers, Ed. 12, 123. Paris.

§ Floral development on a spur, *lambourde*.

‖ In horticultural literature an "eye" is a bud that will produce a leafy axis, and a "bud," or "fruit-bud," is a bud that will produce a floral axis.

practically the normal mode of development. Developing at the same time as the flowers at the base of the floral axis or purse, these eyes become ordinarily during the same season, buds crowned by three or four leaves, unless an exuberance of sap forces them to grow into leafy shoots. During the second year they develop into buds crowned by six to eight leaves, or floral buds and develop into flower clusters the third. It is due to the fact that the purse eyes require two years to form flowers that we have alternation of floriferousness in the orchard-grown pome fruits when they are in full bearing and consequently growing moderately. The first year of the development of the purse eyes coincides with the bearing year.

The infertile year which follows is the second year of the existence of the purse eyes which develop that year into flower buds. These latter opening the following year give rise to another floriferous year and so on for succeeding years.

A study of the method of flowering of the apple will show that Courtois's explanation was sound and that it satisfactorily explains biennial bearing.

In our fruit trees we may distinguish two classes of branches: 1. Branches of the first order, or structural branches; 2. Branches of the second order, or fruit branches.

A structural branch in its first year of growth is called a leader.

Fruit branches, on the other hand, are of several kinds. In the case of the apple we can distinguish: (1) The fruit branch (*rameau à fruit*); (2) The sprig (*brindille*); (3) The dart (*dard*); (4) The spur* (*lambourde*).

A *fruit branch* is a leader in which the terminal and axillary buds in the upper two thirds or thereabouts of its length become flower buds during the season of its development (PLATES 1, FIG. 2, and 2). The flower buds borne laterally on the leader have been described as formed axillarly by D'Albret† and by Gourley,‡ though they are in reality borne terminally on almost sessile spurs (*lambourdes*). A close study during the first season of the buds from which the supposed axillary clusters arise will show that at the close of vegetation the buds are subtended by a rosette of leaves and are not in the axil of a single leaf. The buds are, therefore, terminal on sessile spurs and not axillary, as by definition an axillary bud is a bud borne in the axil of a leaf. Forney is also of this opinion for he states that "it often happens that the eyes of this season's leader become transformed at once into spurs, and flower perfectly the following year."* In the apple the development of flower buds on fruit branches is not commonly met with (see TABLE I) and is said to occur only in very fertile trees, or trees weakened by transplantation or soil exhaustion.

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* The *dard* and *lambourde*, which I have distinguished from one another, are called indiscriminately spurs in the Anglo-Saxon horticultural literature.

† D'Albret. La taille des arbres fruitiers, Ed. 4, 7. Paris. 1842.

‡ Gourley, J. H. Studies in fruit bud formation. New Hampshire Agr. Exp. Sta. Tech. Bull. 9, 17. 1915.

The *sprig* (*brindille*) is a shoot about a foot or so in length which develops from two-year-old wood, from dormant eyes in older wood, or even from purse eyes. The sprig produces not infrequently a terminal flower-bud the year of its formation, thus behaving in a very similar manner to a leader that has become a fruit branch. In the apple the sprig is not an uncommon form of a fruit branch.†

The *dart* (*dard*) is a short, stout branch possessing smooth bark and growing out from the supporting branch at about a right angle, in its most typical form, that is, when derived from a spine. In its atypical form (PLATE 3, FIG. 1), the only one met with in the apple, it is simply a very short spine-like branch with smooth bark. The dart may also develop from a purse and it is usually considered that the health and vigor of a spur depends on its having been derived from a dart or to the development of a dart or darts at some subsequent time (PLATE 1, FIG. 1). In very fertile varieties of the apple the dart may produce a terminal flower-bud the year of its formation.‡ Usually, however, it only flowers the third year. When the dart forms a flower bud the first season of its growth the floral bud will be found nestling in a rosette of leaves, the apex of the dart having become immediately transformed into a spur (*lambourde*). But if the floral bud is to form at the end of the second season then the apical bud will behave in the manner characteristic of the apical buds of a spur at the close of the first year's vegetation, that is it will be subtended by a rosette of three or four leaves.

The *spur* (*lambourde*) (PLATE 3, FIG. 2), is a short, thick, brittle branch with much wrinkled bark and breaking readily with a smooth fracture. The crests of the wrinkles are nodal points, the troughs internodal points. The axillary buds are very inconspicuous and usually remain dormant though they can be made to develop by appropriate means. The spur usually develops from a bud formed during the previous year, that is from two-year-old wood, and requires two seasons' growth to form a flower bud. At the end of the first year the apical bud will be surrounded by a rosette of three to four leaves, and at the end of the second by a rosette of six to eight leaves, and will have become a floral bud, though spurs may develop on a purse that are fertile the year of their formation behaving in this respect like the spurs of a fruit branch. A spur may live for a number of years becoming with age more or less branched, depending on the degree to which the eyes of the floral axes, or purses develop (PLATE 1, FIG. 1).

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* Forney, E. Taille des arbres fruitiers, Ed. 2, 1: 258. Paris. 1907.

† Barry, P. The fruit garden, 11. New York. 1851; Forney, *loc. cit.* 1: 254.

‡ Berne, A. Manuel d'arboriculture fruitière, 69. Grenoble. 1898; De Mortillet, M. P. Les meilleurs fruits 3: 376. Montpellier. 1868.

Besides the methods of flower-bud formation already described one other method deserves to be described. In orchards where second growth occurs it is not infrequently observed that the terminal buds become flower buds immediately.* It should, however, be noted that this mode of florification is not exceptional in its manner of development. Second growth, except in point of origin, is of the nature of a sprig (*brindille*) and we have seen that on this type of fruit-branch apical flower buds form commonly the first year of its development. We have seen, furthermore, that axillary buds on a leader could develop spurs which bore flowers the following season, that spurs could develop on a purse that were fruitful the following season; that the apical bud of a leader also sometimes developed into a spur which flowered the following season. Now it is to be noted that the flower-buds formed in the several ways above mentioned have this one point in common: they grow on the end of a shoot that develops six to eight sessile nodes in a single period of vegetation. In other words an apical bud subtended by six to eight sessile nodes will be a flower-bud, irrespective of the type of branch upon which it develops. The development of the flower-buds is then clearly correlated with growth. But this growth must be sessile, in other words extremely slow and quick maturing, conditions that can only be supplied by a scant but sufficient water supply coupled with conditions favorable for photosynthetic activity.

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* Van Mons, L. B. Arbres fruitiers 1: 108. Louvain. 1835; Gourley, J. H., *loc. cit.*

Of the various ways in which flower buds form in the apple, we may dismiss as of absolutely no importance from the point of view of crop production, flower bud development on second growth, and the same may be said of flower bud development on spurs from leaders of the same age. The following table will show quite clearly that such floral buds produce as a rule but a small part of the total bloom, and this despite the fact that the data were taken by counting random branches round individual trees from the apex of a leader down the branch for a convenient distance.

TABLE I

RELATIVE IMPORTANCE OF SPURS AND FRUIT BRANCHES IN CROP PRODUCTION

Variety	Number of trees examined	Blossom on spurs, per cent.	Clusters on fruit branches, per cent.
Red Astrachan	2	100	0
Early Harvest	2	100	0
Bellflower	1	87.6	12.4
Lyscomb	1	99.42	0.58
Rhode Island Greening	1	100	0
Fallawater	1	90.5	9.5
Duchess	1	98.2	1.2
Wagener	1	89.8	10.2
McIntosh	1	94.6	5.4
Wealthy	2	62.3–95	37.7–5.0
Baldwin	15	100–89.4 (mean 99.09)	0.0–10.6 (mean 0.91)
Peck's, Pleasant	2	98.75–97.9	1.25–2.1
Transcendant Crab	1	80.6	19.4

On apple trees of bearing age the leaders may develop apical flower buds during the first year. But this mode of bearing does not play a material part in the total yield of a tree. The crop of apples, at least in years when the yield is good, is produced by the spurs. Let us study, therefore, the behavior of the spurs following their first productive year.

We have seen that a spur usually develops from an axillary bud on two-year-old wood and forms an apical bud subtended by a rosette of three to four leaves, which develops next year into a very short growth bearing a bud subtended by a rosette of six to eight leaves, and experience has shown that such a bud is invariably a flower bud, whereas the apical bud with a rosette of three to four leaves is only potentially floriferous. The flower bud of the apple is a mixed bud, and to this fact we owe certain peculiarities in the growth of spurs to which attention must now be called.

After the flowers have been pollinated and the fruit has set the lower and leafy portion of the floral axis becomes considerably thickened and pursey (PLATE 1, FIG. 1), hence the name *bourse* given to it by the French and which Dr. Black* has very appropriately anglicized purse. On this purse one or two axillary buds either become spurs, darts or sprigs, or if placed terminally on a leader may and usually do develop a shoot. The spurs form during the current year and either flower the following spring, or, and customarily only do, develop a flower-bud during the second season and bloom in the third, but, should the purse eyes remain dormant the year of their formation then the spurs would not bloom until the fourth year; the darts, which develop readily on purses (see PLATE 1, FIG. 1) and sprigs flower in the usual way.

Owing to the fact that with few exceptions, spurs only flower on alternate years it must follow that after an apple tree begins to form new growth slowly and bear heavily, a light crop must necessarily follow a heavy crop, for, when the flowering of the spurs synchronizes to such an extent as to give a large yield, the same spurs are not in a position to bear again until the next succeeding year. Alternate bearing in mature apple trees is, therefore, a natural phenomenon and one that could be predicated from the mode of flowering of the tree.

III

Alternate bearing of the apple has been ascribed very generally to exhaustion following the productive year, but this opinion appears to be without foundation, for it is commonly observed that an apple grows well following a productive year which would not possibly be the case were the tree exhausted. Again if the tree were exhausted when it bore heavily it is to be presumed that the spurs would require a longer time to produce flowers than they do when production is light, for a spur weakened from any cause is not a fruitful spur any more than is one that develops with too much vigor. Nor is there any particular justification in Gourley's view† that there is a relation between the amount of starch stored and flower bud development. Flower buds may be developed on one-year-old wood by defoliation, cutting back,* or cutting into the wood above the eyes as is done when lifting a bud.†

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* Black, C. A. The nature of the inflorescence and fruit of *Pyrus Malus*. Mem. New York Bot. Gard. 6: 521. 1916.

† Gourley, J. H. *loc. cit.*

These several methods, dissimilar as they may appear, all cause increase in sap pressure and not an increase in stored starch, behind the buds which thereupon grow into short spurs with apical flower buds. The difference in starch content between fruitful spurs and barren spurs is an effect of the mode of vegetation, not the cause of it. An inspection of fruit spurs will show that those bearing flower buds have more leaves per unit length than those bearing leaf buds and consequently should contain more starch.

But if the theory that alternate bearing is due to exhaustion has little or no foundation, the remedies that have been proposed to overcome the debilitating effect of fruitfulness are not for the most part without value.

According to Beach "systematic thinning of fruit combined with skillful care in other directions, may materially strengthen the tendency of the tree to bear annually"‡ a statement which can not be considered a strong endorsement of the value of thinning for the purpose of equalizing crop production; and effectively a year later we find the same author concluding as a result of experiments on thinning carried out for several successive years that "thinning the fruit did not appear to cause any material change in either the amount or regularity of fruit production,"§ a view that must be considered substantially correct as we shall see.

Thinning the fruit can not be expected to effectively regularize bearing for the reason that this operation can have but the following effects upon the tree:

1st, Thinned trees produce *ceteris paribus* more new growth than non-thinned trees; 2d, The sap drawn into the spurs to maintain the fruit, is diverted after thinning into the eyes of the purse which develop more fully than they otherwise would have done.

The increased growth produced by thinning will, in the normal course of events, flower only in the third year after the thinning was effected, in other words, the growth produced as a result of thinning will become productive a year later than the spurs that were fruitful during its first year of growth and consequently a certain regulatory effect will be produced, the magnitude of which can be estimated in advance by the number of spurs formed.

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* Van Tieghem, Ph. Traité de botanique, Ed. 2, 1: 961. Paris. 1892.

† Baron, Philibert. Nouveaux principes de taille des arbres fruitiers. 1858.

‡ Beach, S. A. The thinning of fruit. California fruit grower 27: 4. 1902.

§ Beach, S. A. Thinning apples. New York Agr. Expt. Sta. Bull. 239: 198. 1903.

As regards the effect of thinning on the fructification of the spurs it should be noted that the purse eyes normally only bloom the third year, though they may, as Goff has pointed out,[*] bloom the second season, but such behavior is exceptional and there is no evidence at present that thinning advances the time of blooming of the purse eyes.

The value of thinning in regularizing bearing must be small, though there can be little doubt but that it is an adjuvant.

Various cultural operations and methods of fertilization have, as would be expected, quite marked results on the regularity of bearing of apple trees. This is, of course, not surprising. Cultural methods affect markedly the vigor and productivity of plants and it is easy to understand that in any given soil and situation the optimum would be obtained by some one method of treatment rather than another. The data presented in the following table is in this respect instructive.

TABLE II

EFFECT OF CULTURAL METHODS ON PRODUCTIVITY AND REGULARITY OF BEARING OF NORTHERN SPY AND BALDWIN APPLES[†]

Cultural method employed	Mean yield	1907	1908	1909	1910	1911	1912	1913[‡]	1914	1915
	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.
Tillage and cover-crop	364	−341	+103	−169	+141	−162	+117	+161	+148	+ 2
Tillage, cover crop and stable manure	381.5	−264.5	−236.5	+111.5	−165.5	+230.5	−193.5	+272.5	+364.5	−118.5
Tillage, cover-crop and chemical manure	420	−291	−298	+219	−302	+153	−259	+407	+180	+191
Sod-mulch	327.2	−298.2	−106.2	−112.2	+ 63.8	− 81.2	+111.8	+199.8	+110.8	+111.8
Sod-mulch and stable manure	470.7	−386.7	−255.7	+ 22.3	+ 55.3	+150.3	− 57.7	+282.3	+242.3	− 51.7
Sod-mulch and chemical manure	417.5	−379.5	−218.5	− 8.5	+142.5	− 47.5	− 1.5	+275.5	+121.5	+116.5

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[*] Goff, E. S. Investigation of flower buds. Wisconsin Agr. Exp. Report 17: 283. 1900.

[†] After data by Stewart, J. P. Cultural methods in bearing orchards. Pennsylvania Agr. Exp. Sta. Bull. 141: 23. 1916.

[‡] In 1913 the Baldwin was seriously and irregularly affected by frost and the yield for the Northern Spy only is given.

The data in the above table show that in the trees under tillage alternate bearing is more pronounced than in the trees under sod-mulch; and that fertilization emphasized alternate bearing whether the trees were in sod-mulch or under cultivation. The trees grown in sod-mulch without fertilization bore more uniformly than under any of the other cultural methods used, which signifies that in the trees so treated there was a more uniform yearly production of spurs than in the others, which in other words means that the yearly growth of the trees must also have been more uniform.

An example will make the above statement clear. Let us assume that we have an apple tree in full bearing and that we have six consecutive years of bearing wood already formed. Let us say that the youngest growth developed in 1916, then the oldest was produced in 1908. Now if the yearly growth has been equal throughout, the number of spurs formed will have been equal and the crops produced identical (TEXT FIG. 1).

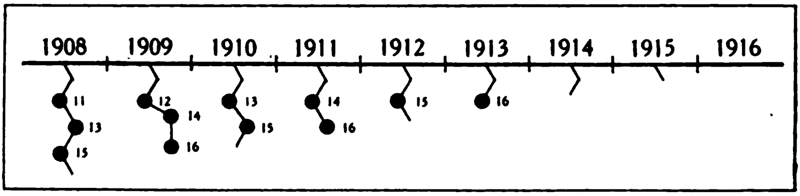

FIG. 1. Diagrammatic drawing showing method of fruiting of the apple.

● = Bearing year; the numbers subjoined in the figure indicate year of fruitfulness.

\ = One year's growth.

> = Two years' growth.

Now let us suppose that the yearly growth was unequal, then the number of spurs formed will have been unequal and productiveness will have exhibited corresponding fluctuations.

There is, therefore, a direct relation between growth and productiveness. In order to produce annual bearing in the apple, and this is a *sine qua non*, one must cause the development of flower-buds to take place in about equal numbers every year. In other words, the bearing surface of an apple tree after it has reached maturity should not be allowed to change, which means that the new growth should be regular and always sufficient to compensate for the decrease in fertility and death of the spurs on the older bearing wood. Pruning may be considered as the most potent means of regularizing bearing, in fact the only really effective means of accomplishing this object, as Columella* pointed out long ago. By pruning one can maintain the proper balance between vegetative vigor and reproductive vigor. By judicious pruning spurs can be made to develop in proper number so as to fully garnish the two-year-old wood and even to form on the current season's growth.† Again the spurs themselves can be rendered more productive by judicious pruning.‡

In conclusion I would lay down the following axiom: To obtain regular fruitfulness in apple trees of bearing age the yearly departures from the mean growth must be small.

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* Columella, L. J. M. De rei rustica. Venice. 1523.

† Van Tieghem, Ph. *loc. cit.* Baron, *loc. cit.*

‡ Hardy, *loc. cit.* Forney, *loc. cit.*

Description of plates 1-3

PLATE 1

FIG. 1. An old spur showing mode of growth and component parts:—spurs, purses and darts.

FIG. 2. A fruit branch taken from a Transcendant Crab showing lateral inflorescences on sessile spurs.

PLATE 2

A fruit branch taken from a Wealthy apple, showing the lateral inflorescences borne on very feebly developed spurs.

PLATE 3

FIG. 1. A dart in flower.

FIG. 2. A spur in flower.

Meadow vegetation in the montane region of northern Colorado

E. L. REED

(WITH ONE TEXT FIGURE)

The meadows here considered are chiefly those of a mountain park, Boulder Park, at Tolland, in the montane region of northern Colorado, at an altitude of 2,710 m. Reference is also made to some meadows at lower altitudes, likewise to some of the subalpine region.

Boulder Park (FIG. 1) is a small treeless valley about 3.2 km. long by 1.2 km. wide, surrounded by hills covered with forests of conifers and aspens. South Boulder Creek flows in a winding course through the length of the park. The floor of the park is covered with glacial drift in the form of morainic knolls and sinks and flat terraces formed by a rearrangement of the glacial deposits through the action of running water. Drift material is also present

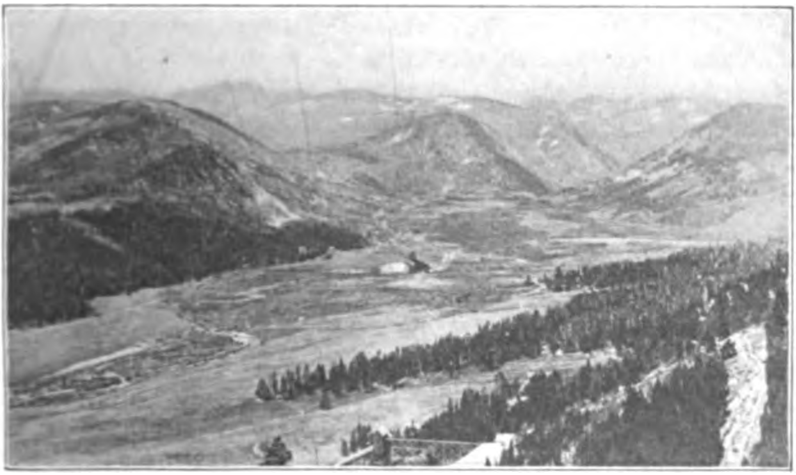

FIG. 1. View of Boulder Park (Tolland, Colorado) looking west to the Continental Divide. Meadow vegetation is developed along the Creek, around the ponds and on certain hillsides, especially above the lake at the right of the picture. Photograph by Dr. G. S. Dodds.

on the lower parts of the surrounding hills. The vegetation of the park forms itself naturally into the following communities: sedge moor, willow scrub, meadow, and dry grassland (see Ramaley, 1). The mesophytic portion of the grassland, which is characterized by meadow grasses, sedges, and flowering herbs closely set so as to expose very little bare ground, is here termed meadow. It is with the meadow vegetation primarily that the present paper is concerned. The meadow association occurs along streams and around ponds, lying just above the willow scrub. It is bordered in turn by dry grassland or else by coniferous forest. The width of the meadow zone along streams is 1–10 m. or more, but there are hillside meadows also, one in particular being about 300 × 600 m. in extent.

ENVIRONMENTAL FACTORS

The high altitude of Boulder Park and its proximity to the snow-covered peaks of the Continental Divide give it a severe climate. There is considerable snow in winter and frequent showers occur in spring and summer. The annual rainfall is thought to be about twenty-eight inches and the mean annual temperature 40° F. with a mean for July of about 58° F. The maximum temperature known for July is 82° F., and the minimum, 32° F. Scarcely a week passes without frost, while ice is formed frequently in July and August (see Ramaley, 2).

The soil of the meadows is a loose sandy loam two to ten decimeters thick. The subsoil is composed of coarse gravel. Determinations of soil moisture and temperature were made each season. The results are shown in TABLES I and II.

TABLE I

SOIL TEMPERATURES AT A DEPTH OF 30 CM.

July, 1915, average of twenty-three readings,	53.6° F.
July, 1916, average of fifteen readings,	56.4° F.

TABLE II

SOIL MOISTURE AT DEPTH OF 30 CM.

July, 1915, average of fourteen determinations,	16.7 per cent.
July, 1916, average of five determinations,	16.3 per cent.

By way of comparison it may be stated that the soil temperature of the dry grassland societies shows 64° F. for the July average and that the soil moisture shows 4.6–9.1 per cent (see Ramaley, etc., 1, 2, 3).

SEASONAL ASPECTS

This study was carried on in 1915 and 1916 during two sessions of the University of Colorado Mountain Laboratory, extending from the last week in June to the first week in August. This embraces the summer season only, hence the spring and autumn aspects will be omitted.

Early summer is characterized by a profusion of flowers; grasses and sedges also are to be seen but they are not yet in bloom. The most conspicuous plants are *Thermopsis divaricarpa, Pseudocymopterus tenuifolius, Castilleia sulphurea*, and *Pedicularis Parryi*. The green of the foliage and yellow of the blossoms give the meadows at this time a yellowish green hue.

Late summer has a great profusion of flowering dicotyledons interspersed with grasses. The conspicuous plants in flower are *Campanula petiolata, Delphinium robustum*, and three species of *Potentilla*. These give the meadows either a bluish green or a yellowish green hue, depending upon whether the *Campanula* and *Delphinium* or the species of *Potentilla* predominate.

SOCIETIES

Owing to the varying conditions of moisture, differences in soil texture, and depth to subsoil, various societies may be distinguished. The genetic relationship of the several societies has not been studied. The following seem fairly well marked and with each a few species of the most prominent plants are given:

1. *Pedicularis-Pseudocymopterus Society*.—In certain of the drier portions of the meadows. *Pedicularis Parryi, Pseudocymopterus tenuifolius, Tium alpinum, Sieversia ciliata, Potentilla pulcherrima, Carex festiva, Festuca ingrata, Phleum alpinum*

2. *Thermopsis-Castilleia-Campanula Society*.—Characteristic of drier portions of hillside meadows. *Thermopsis divaricarpa, Castilleia sulphurea, Campanula petiolata, Bistorta bistortoides, Helianthella quinquenervis, Calochortus Gunnisonii, Allium Geyeri, Valeriana furfurascens, Festuca confinis, Phleum pratense, Stipa Nelsonii, Bromus Porteri, Danthonia Parryi*. This society has

two seasonal aspects: (*a*) early summer aspect with *Thermopsis divaricarpa* and *Castilleia sulphurea* dominant; (*b*) late summer aspect with *Campanula petiolata* dominant.

3. *Campanula-Eriogonum Society.*—This society is rather typical of the drier portions of the meadow especially that bordering on dry grassland. *Campanula Parryi, Eriogonum subalpinum, Galium boreale, Achillea lanulosa, Erigeron macranthus, Artemisia gnaphaloides, Stipa Nelsonii.*

4. *Pentstemon-Agoseris Society.*—This society is common in glacial sinks where the soil is deep and only moderately wet. A few invasions from the surrounding dry grassland are sometimes found. *Pentstemon procerus, Agoseris glauca, Valeriana furfurascens, Pedicularis Parryi, Achillea lanulosa, Potentilla pulcherrima, Mertensia Bakeri, Festuca pseudovina, Danthonia intermedia.*

5. *Potentilla-Fragaria Mixed Society.*—This society is typical of meadows along streams. There are no species that distinguish the society, but a number are present in almost equal abundance and the plants named are all well represented. *Potentilla pulcherrima, P. Hippiana, Fragaria glauca, Galium boreale, Valeriana furfurascens, Achillea lanulosa, Sieversia ciliata, Pseudocymopterus tenuifolius, Erigeron eximius, Dasystephana Parryi, Tium alpinum, Thalictrum Fendleri, Trifolium repens, Danthonia Parryi, D. intermedia, Koeleria cristata, Festuca rubra, Agrostis hiemalis, Stipa Nelsonii.*

6. *Dasiphora-Valeriana-Delphinium Society.*—A society seen on moist gravelly soil well supplied with water. *Dasiphora fruticosa, Valeriana furfurascens, Delphinium robustum, Fragaria glauca, Erigeron eximius, Galium boreale, Iris missouriensis, Caltha leptosepala, Pedicularis Parryi, Agoseris glauca, Pentstemon procerus, Achillea lanulosa, Tium alpinum, Pseudocymopterus tenuifolius, Sieversia ciliata, Campanula petiolata, Aragallus deflexus, Dasystephana Parryi, Castilleia sulphurea, Bistorta bistortoides, Potentilla pulcherrima, P. Hippiana, Aragallus Richardsonii, Carex festiva, Deschampsia caespitosa, Stipa Nelsonii, Festuca Thurberi, Koeleria cristata.*

7. *Deschampsia-Valeriana Society.*—A society of fine-grained moist soil bordering sedge moors. *Deschampsia caespitosa, Valeriana furfurascens, Thermopsis divaricarpa, Thalictrum Fendleri,*

Castilleia sulphurea, Potentilla pulcherrima, Achillea lanulosa, Iris missouriensis, Dasystephana Parryi, Dasiphora fruticosa, Agoseris glauca, Carex festiva.

QUADRAT DETERMINATIONS

In addition to a general study of the meadows, two 2 m. quadrats were examined in detail according to the plan developed by Professor Ramaley in his study of dry grassland (4). Of course such small tracts would not contain all the species in the meadow, but they had more than one fourth of all the meadow plants. TABLE III shows the results of this quadrat study.

TABLE III

SPECIES IN THE QUADRATS WITH APPROXIMATE PERCENTAGE OF GROUND COVERED BY EACH

Species	Percentage of ground covered Quadrat 1	 Quadrat 2
Botrychium Lunaria	1	
Grasses	21	3
Carex festiva	2	1
Juncus balticus montanus	3	1
Calochortus Gunnisonii		1
Sisyrinchium angustifolium	1	
Cerastium occidentale	1	1
Delphinium robustum	1	1
Ranunculus cardiophyllus	1	1
Thalictrum Fendleri		11
Arabis glauca		1
Micranthes rhomboidea	1	
Dasiphora fruticosa	1	
Fragaria glauca		8
Potentilla gracilis	1	
Potentilla pulcherrima	4	4
Aragallus Richardsonii	2	
Aragallus deflexus	1	
Thermopsis divaricarpa		1
Ttum alpinum	13	11
Pseudocymopterus tenuifolius	2	1
Dasystephana Parryi	1	1
Chondrophylla Fremontii	1	
Castilleia sulphurea		2
Pedicularis Parryi	7	
Pentstemon procerus	4	
Galium boreale		2
Campanula petiolata	1	1
Valeriana furfurascens		1

Achillea lanulosa	1	3
Antennaria anaphaloides	6	
Artemisia Forwoodii	1	
Arnica fulgens		1
Carduus griseus		2
Agoseris glauca	5	2
Crepis perplexa	2	
Taraxacum Taraxacum	1	
Bare ground	15	12

WATER REQUIREMENTS OF VARIOUS PLANTS

The plants of the meadows may be classified according to their usual water requirements or better the amount of moisture in the soils they frequent. Following a plan used by Professor Ramaley in his lectures on ecology, the meadow plants are given the index numbers 5, 6, and 7. Those that grow most commonly in the drier parts of the meadow are numbered 5, those in the wettest parts 7, while the typical mesophytes are numbered 6.

In meadows that are along streams or ponds it is often possible to recognize about three zones, these being characterized by different amounts of moisture in the soil. Some plants are restricted to a single zone while others may grow in two or more but, with few exceptions, not in equal abundance. Certain plants, as *Achillea*, grow well in all three zones but are seldom in great abundance anywhere.

In the systematic list of meadow species given below the relative soil moisture with which the various species are usually associated is indicated by one or more of the figures 5, 6, or 7. The figure which represents the normal condition for the species is italicized.

DURATION OF INDIVIDUAL PLANTS

The majority of the meadow plants are perennials living for many years. Thirteen species, representing nine per cent. of the flora, are annuals. These are *Polygonum Englemannii*, *Alsine baicalensis A. longipes*, *Draba nitida*, *Epilobium paniculatum*, *Gayophytum ramosissimum*, *Androsace subulifera*, *Amarella plebeja*, *Chondrophylla Fremontii*, *Collomia linearis*, *Collinsia parviflora*, *Orthocarpus luteus*, *Rhinanthus Crista-galli*. Five species, representing three per cent. of the flora, are biennials. These are *Allium* *recurvatum*, *Arabis divaricarpa*, *A. hirsuta*, *Potentilla monspeliensis*, *Lappula floribunda*. Of the annuals and biennials, *Allium recurvatum* is the only one that appears in any great abundance; the others are infrequent.

FREQUENCY OF OCCURRENCE OF DIFFERENT SPECIES

The various species do not occur with the same frequency in each meadow. Some are found in great profusion either locally or widely distributed. Others, which likewise may be either local or widely distributed. are never found abundantly in any place. In the following list frequency is indicated by letters: (*a*) abundant, (*f*) frequent, (*o*) occasional.

SYSTEMATIC LIST OF MEADOW PLANTS IN BOULDER PARK WITH THEIR FREQUENCY AND WATER REQUIREMENTS

OPHIOGLOSSACEAE

Botrichium Lunaria (o) 6, 7

POACEAE

Agrostis hiemalis (*f*) 6
Agropyron pseudorepens (*a*) 5, 6
Agropyron caninum (*a*) 6
Agropyron Richardsonii (*f*) 6
Avena americana (*f*) 5, 6
Bromus lanatipes (*f*) 5, 6
Bromus Porteri (*a*) 6
Calamagrostis canadensis (*f*) 7
Danthonia intermedia (*f*) 6
Danthonia Parryi (*e*) 5, 6
Deschampsia caespitosa (*a*) 6, 7
Elymus glaucus (*f*) 7
Festuca confinis (*f*) 6
Festuca ingrata (*f*) 6
Festuca pseudovina (*a*) 5, 6
Festuca rubra (o) 6
Festuca Thurberi (*a*) 5, 6
Koeleria cristata (*a*) 5, 6
Phleum alpinum (*f*) 5, 6, 7
Phleum pratense (*f*) 5, 6
Poa epilis (*f*) 5
Poa interior (*f*) 5, 6
Poa nevadensis (*f*) 6
Poa rupicola (*f*) 6
Poa subpurpurea (*a*) 5, 6
Savastana odorata (*a*) 6, 7
Sitanion longifolium (*f*) 5
Sitanion brevifolium (o) 5
Sporobolus asperifolius (*f*) 6, 7
Stipa Nelsonii (*a*) 5, 6
Stipa Minor (*f*) 5, 6
Stipa viridula (*f*) 6
Trisetum subspicatum (*f*) 5, 6

CYPERACEAE

Carex festiva (*a*) 6, 7
Carex lanuginosa (*f*) 7
Carex occidentalis (*f*) 7
Carex pennsylvanica (*f*) 6, 7
Carex utriculata (*f*) 7

MELANTHACEAE

Anticlea elegans (*f*) 6

JUNCACEAE

Juncus balticus montanus (*a*) 5, 6
Juncus saximontanus (*f*) 7

ALLIACEAE

Allium Geyeri (*a*) 5, 6
Allium recurvatum (*a*) 5, 6

CONVALLARIACEAE

Vagnera stellata (*f*) 5, 6

CALOCHORTACEAE

Calochortus Gunnisonii (*a*) 6

IXIACEAE

Iris missouriensis (*a*) 6, 7
Sisyrinchium angustifolium (*a*) 6

ORCHIDACEAE

Limnorchus viridiflora (*f*) 7

POLYGONACEAE

Bistorta bistortoides (*a*) 5, 6, 7
Eriogonum subalpinum (*f*) 5
Polygonum Englemanii (*f*) 5
Rumex densiflorus (*o*) 7

ALSINACEAE

Alsine baicalensis (*o*) 6, 7
Alsine longipes (*o*) 6, 7
Arenaria Fendleri (*f*) 5, 6
Arenaria Hookeri (*o*) 5
Cerastium occidentale (*a*) 5, 6, 7

CARYOPHYLLACEAE

Silene Hallii (*o*) 5

RANUNCULACEAE

Aconitum ochroleucum (*o*) 7
Aconitum insigne (*o*) 7
Delphinium Nelsonii (*f*) 5, 6
Delphinium robustum (*a*) 6, 7
Ranunculus affinis (*f*) 7
Ranunculus cardiophyllus (*f*) 6
Thalictrum Fendleri (*a*) 5, 6, 7

BERBERIDACEAE

Odostemon aquaefolium (*o*) 5

BRASSICACEAE

Arabis divaricarpa (*f*) 6
Arabis glabra (*o*) 6
Arabis hirsuta (*o*) 6
Bursa Bursa-pastoris (*f*) 5, 6
Draba nitida (*o*) 6
Draba streptocarpa (*f*) 6
Erysimum Wheeleri (*o*) 5

CRASSULACEAE

Sedum stenopetalum (*o*) 5

SAXIFRAGACEAE

Micranthes rhomboidea (*f*) 5, 6

ROSACEAE

Dasiphora fruticosa (*f*) 6, 7
Drymocallis glandulosa (*o*) 5
Fragaria glauca (*a*) 6, 7
Geum oregonense (*f*) 6, 7
Potentilla filipes (*o*) 6
Potentilla gracilis (*f*) 5, 6
Potentilla Hippiana (*a*) 5, 6
Potentilla monspeliensis (*o*) 6
Potentilla pulcherrima (*a*) 5, 6
Sieversia ciliata (*a*) 5, 6, 7

FABACEAE

Aragallus Lambertii (*a*) 5, 6
Aragallus Richardsonii (*a*) 5, 6
Aragallus deflexus (*f*) 5, 6
Atelophragma elegans (*f*) 6
Homolobus flexuosus (*f*) 5, 6
Thermopsis divaricarpa (*a*) 5, 6
Tium alpinum (*a*) 5, 6

GERANIACEAE

Geranium nervosum (*a*) 7

LINACEAE

Linum Lewisii (*a*) 6

MALVACEAE

Sidalcea candida (*f*) 7

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Hypericum formosum (*f*) 7

EPILOBIACEAE

Chamaenerion angustifolium (*f*) 5, 6
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Epilobium rubescens (*a*) 5, 6
Gayophytum ramosissimum (*a*) 6

AMMIACEAE

Heracleum lanatum (*o*) 7
Pseudocymopterus tenuifolius (*a*) 5, 6

PRIMULACEAE

Androsace subulifera (*f*) 6
Dodecatheon radicatum (*o*) 7

GENTIANACEAE

Amarella plebeja (*o*) 6
Chondrophylla Fremontii (*o*) 6, 7
Dasystephana Parryi (*a*) 6

POLEMONIACEAE

Collomia linearis (*f*) 6

HYDROPHYLLACEAE

Hydrophyllum Fendleri (*f*) 6

BORAGINACEAE

Lappula floribunda (*f*) 5
Mertensia viridula (*o*) 6
Mertensia Bakeri (*o*) 5

RHINANTHACEAE

Castilleja Crista-galli (*o*) 6
Castilleja sulphurea (*a*) 5, 6
Collinsia parviflora (*o*) 6
Orthocarpus luteus (*o*) 5
Pedicularis Parryi (*a*) 5, 6
Pedicularis Grayi (*o*) 5
Pentstemon procerus (*a*) 5, 6
Rhinanthus Crista-galli (*f*) 6, 7

RUBIACEAE

Galium boreale (*a*) 5, 6

CAMPANULACEAE

Campanula Parryi (*f*) 5, 6
Campanula petiolata (*a*) 5, 6

Valerianaceae

Valeriana furfurascens (a) 6, 7
Valeriana micrantha (a) 5, 6

Carduaceae

Achillea lanulosa (a) 6
Antennaria anaphaloides (a) 5
Antennaria imbricata (a) 5, 6
Antennaria microphylla (f) 5
Antennaria oxyphylla (f) 5
Antennaria rosea (f) 5
Arnica fulgens (f) 6, 7
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Erigeron macranthus (f) 6
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Helianthella quinquenervis (a) 6
Rudbeckia flava (a) 6, 7
Senecio crocatus (f) 6
Senecio perplexus (f) 6
Senecio scopulinus (o) 6
Senecio triangularis (o) 7
Solidago concinna (o) 6
Solidago missouriensis (f) 6

Cichoriaceae

Agoseris glauca (a) 6
Agoseris Greenei (f) 6
Agoseris purpurea (a) 6
Agoseris aurantiaca (o) 6
Crepis perplexa (a) 5, 6
Taraxacum Taraxacum (f) 6

Meadows of the lower montane region

A comparison of the meadows of Boulder Park with those of the lower montane region shows that, in the main, the same plants are present but that the predominant plants in the lower meadows become secondary or may even be absent from the meadows of the park. At lower altitudes, introduced plants have supplanted largely the native species and have often become dominant as the following lists show:

Trifolium-Poa Society.—Trifolium repens, T. pratensis, Tium alpinum, Fragaria glauca, Potentilla pulcherrima, Achillea lanulosa, Juncus balticus montanus, Dasiphora fruticosa, Phleum pratense, Carex festiva.

Trifolium-Phleum Society.—Trifolium repens, Phleum pratense, Trifolium pratensis, Campanula petiolata, Fragaria glauca, Geranium nervosum, Tium alpinum, Achillea lanulosa, Taraxacum Taraxacum, Rudbeckia flava, Deschampsia caespitosa, Carex festiva.

The higher subalpine meadows differ from the meadows of the montane zone in general appearance. Many of them have a grayer aspect due to the presence of sages and the greater hoariness of some of the other plants. The plants here are generally shorter and the vegetation resembles dry grassland in its general aspect. Some of the plants found here are common plants of the montane region but they show a tendency toward dwarfing due to the effects of the more severe climatic conditions. In general there is more open or bare ground than in meadows at lower altitudes. Among the prominent plants are *Pseudocymopterus tenuifolius*, *Bistorta bistortoides*, *Micranthes rhomboidea*, *Pedicularis Parryi*, *Achillea lanulosa*, *Rydbergia grandiflora*, *Sedum stenopetalum*, *Cerastium occidentale*, *Erysimum oblanceolatum*, *Artemisia Parryi*, *Dasiphora fruticosa*, *Campanula petiolata*, *Dasystephana Romanzovii*, *Agropyron violaceum*, *Poa crocata*.

The lower subalpine meadows have the dark green color of the montane meadows but the plants are shorter. The number of grasses present is smaller and these cover less ground; therefore they are not so conspicuous as in the montane zone. Among the prominent plants are the following: *Erigeron elatior*, *E. salsuginosum*, *Chrysopsis villosa*, *Achillea lanulosa*, *Castilleia confusa*, *Tium alpinum*, *Castilleia occidentalis*, *Thermopsis divaricarpa*, *Arnica Parryi*, *Solidago missouriensis*, *Campanula petiolata*, *Chamaenerion angustifolium*, *Helianthella quinquenervis*, *Artemisia Parryi*, *Pseudocymopterus tenuifolius*, *Vaccinium caespitosum*, *Senecio Flintii*, *Juncus Drummondii*, *Carex festiva*, *Stipa minor*, *Agropyron pseudorepens*.

GEOGRAPHIC RELATIONS

The fifty-five most prominent species of the meadow are largely northern plants. One plant only, *Pseudocymopterus tenuifolius*, has a range predominantly southern. Twenty-two range about equally north and south. TABLE IV shows geographic and altitudinal ranges of the predominent plants.

TABLE IV

GEOGRAPHIC AND ALTITUDINAL RANGE OF MEADOW PLANTS

No. of species ranging chiefly to the north	32
No. of species ranging chiefly to the south	1
No. of species ranging to north and south	25
No. of species ranging chiefly higher	10
No. of species ranging chiefly lower	20
No. of species ranging both higher and lower	25

MEADOW PLANTS FOUND IN THE FOREST AND ALONG ROADSIDES

Comparison with a paper by Miss Mary Esther Elder (5) shows that the following plants here listed as meadow plants are also found in Boulder Park along roadsides: *Phleum pratense, Koeleria cristata, Poa pratensis, Festuca rubra, Juncus balticus montanus, Bursa Bursa-pastoris, Potentilla monspeliensis, Fragaria glauca, Trifolium pratense, Trifolium repens, Aragallus deflexus, Chamaenerion angustifolium, Collomia linearis, Chrysopsis villosa, Solidago concinna, Achillea lanulosa, Artemisia Forwoodii, Artemisia gnaphaloides, Taraxacum Taraxacum.*

Comparison with a paper by Miss Katharine Bruderlin (6) shows that the following plants here listed as meadow plants are also found in the Lodgepole Pine forest: *Arenaria Fendleri, Cerastium occidentale, Draba streptocarpa, Erysimum Wheeleri, Sedum stenopetalum, Drymocallis glandulosa, Potentilla pulcherrima, Sieversia ciliata, Aragallus Lambertii, Aragallus Richardsonii, Thermopsis divaricarpa, Tium alpinum, Chamaenerion angustifolium, Amerella plebeja, Castilleia sulphurea, Orthocarpus luteus, Penstemon procerus, Galium boreale, Campanula petiolata, Achillea lanulosa, Antennaria anaphaloides, Antennaria microphylla, Antennaria rosea, Carduus americana, Erigeron macranthus, Erigeron eximius, Agoseris purpurea.*

SUMMARY

The foregoing is a report of a study of the meadows of a high mountain park at Tolland, Colorado, made during two summer seasons. Descriptions of seven societies are given. Societies of the lower montane region are also indicated and the chief characteristics of the subalpine meadows briefly discussed. A list of the meadow plants of Boulder Park with their frequency and soil moisture index is given.

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1911-1916

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Reviews, and papers that relate exclusively to forestry, agriculture, horticulture, manufactured products of vegetable origin, or laboratory methods are not included, and no attempt is made to index the literature of bacteriology. An occasional exception is made in favor of some paper appearing in an American periodical which is devoted wholly to botany. Reprints are not mentioned unless they differ from the original in some important particular. If users of the Index will call the attention of the editor to errors or omissions, their kindness will be appreciated.

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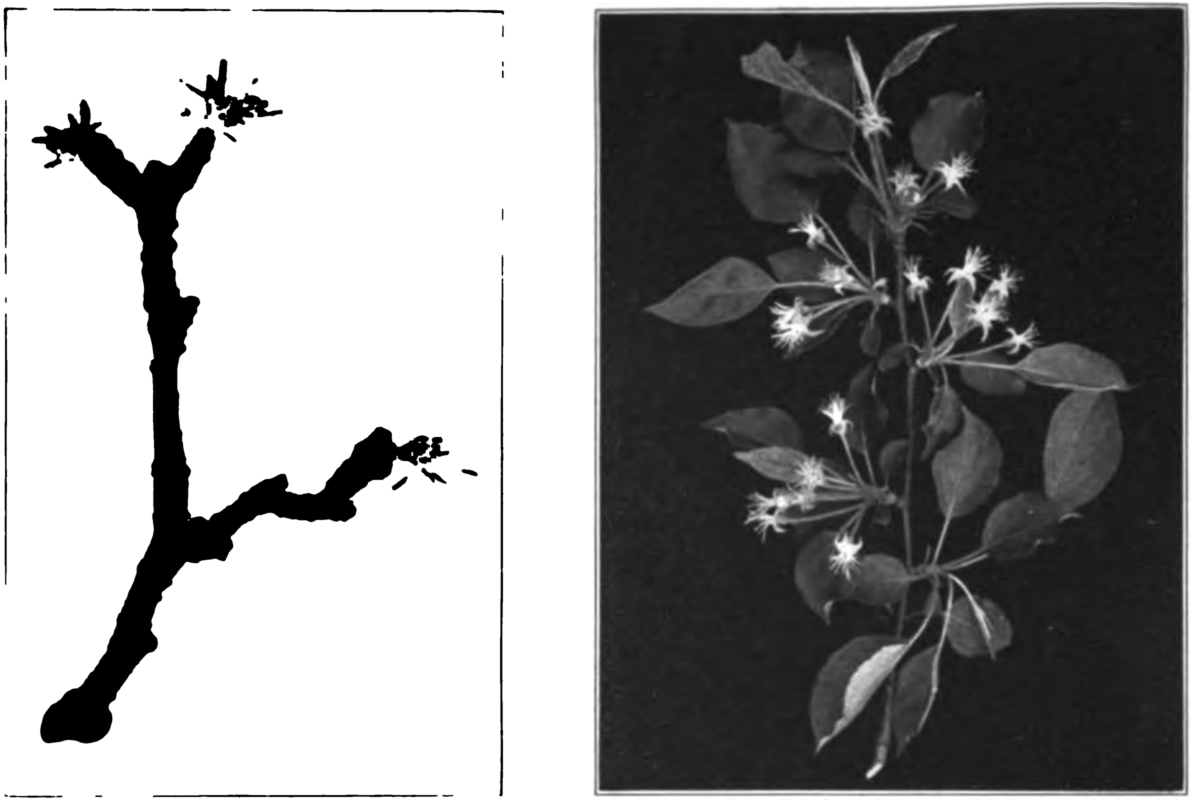

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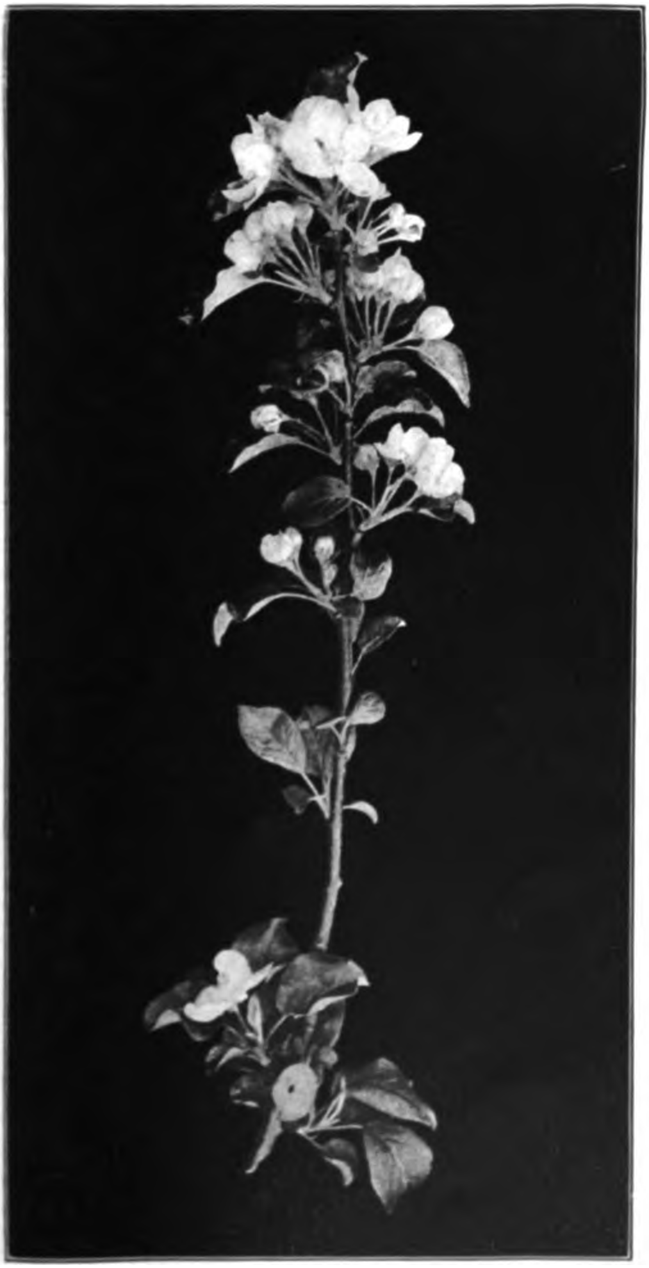

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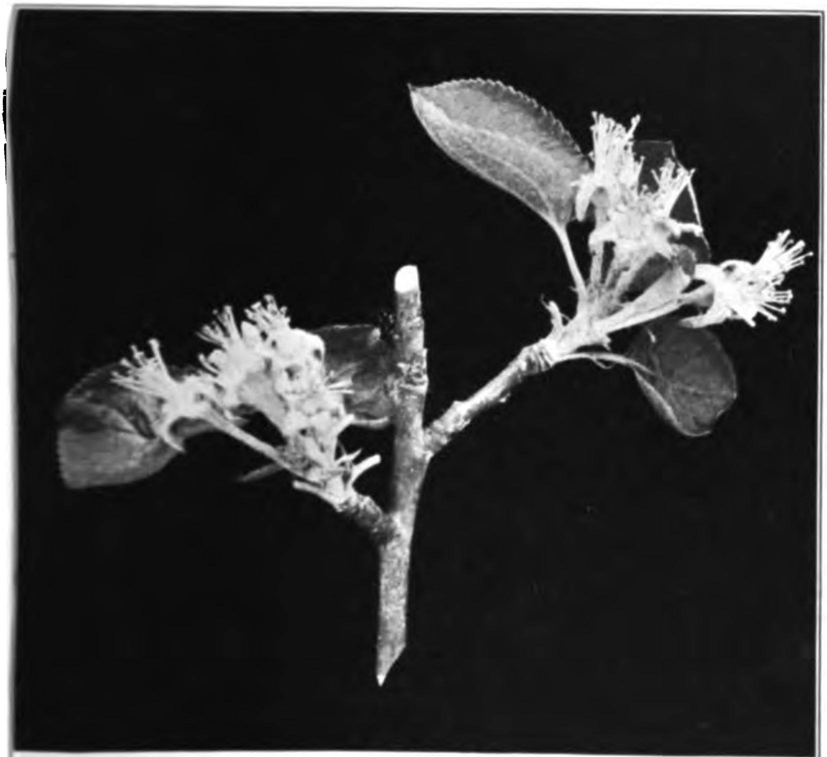

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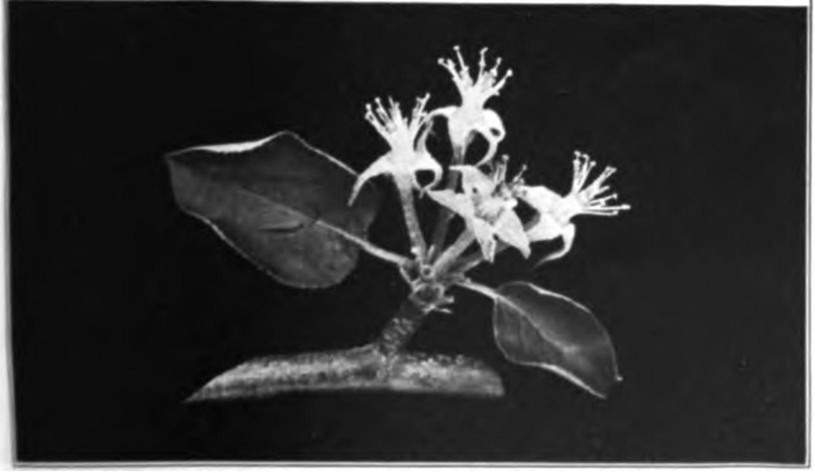

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BUTLER. ALTERNATE BEARING IN THE APPLE

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BULLETIN

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MARCH, 1917.

A revision of the genus Polygonatum in North America

R. R. Gates

(WITH PLATES 4–6)

This genus has been in a very chaotic condition owing to the "lumping" of species, the transference of names, and the confusion of North American with European species. The whole genus contains probably not less than fifty species, the majority of which are European or Asiatic. There has been a marked tendency to form aggregate species of the European forms, so that they too are in need of a critical revision and comparison with North American forms. Not until then will it be possible to determine the closeness of the relationship, though it appears at present that none of the North American species agree with European forms.

The North American forms have been divided by Farwell into two groups, the *Pubescentes* and the *Glabrata*, corresponding respectively to the species which have hitherto been erroneously going under the names *P. biflorum* and *P. commutatum* and which were supposed to comprise all American forms. It may be pointed out that the European alternate-leaved species are also some of them glabrous and some pubescent.

The number of species here recognized is nine, including three, *P. hirtum*, *P. canaliculatum*, and *P. parviflorum*, which are only known from early descriptions. The remaining species show much puzzling variation, so that a number of varieties are recognized, and the limits of variation of several of the species are by no

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means clear at the present time. The only form which appears to be a possible mutation is *P. giganteum*. The interpretation of the origin and relationships of the other species and varieties will have to await a more detailed knowledge of their characters, variation and distribution.

The Euro-Asian members of the genus *Polygonatum*, however, furnish a series of species, such as *P. verticillatum* All. and *P. Haussknechtii* Bornm. & Sint., which agree in having their leaves in whorls, rather than alternate as in American species or opposite as in some European species. This verticillate condition probably did not come about gradually, and must have appeared as a mutation by a single step. Whether this mutation occurred but once, all verticillate species having then descended from a common stock, cannot be debated at the present time, but this is by no means necessarily the case. The fact of parallel mutations of course complicates all interpretations of phylogenetic possibilities.

Unless otherwise stated the specimens cited below are in the herbarium of the Missouri Botanical Garden. The abbreviation "Cal." signifies the herbarium of the University of California.

1. POLYGONATUM PUBESCENS (Willd.) Pursh

Convallaria pubescens Willd. Hort. Berol. 45. *pl. 45*. 1805.

Polygonatum pubescens Pursh, Fl. Am. Sept. 234. 1814; Farwell, Bull. Torrey Club **42**: 253. *pl. 13A*. 1915.

Polygonatum multiflorum β americanum Hook. Fl. Bor. Amer. **2**: 176. 1840 (in part).

Polygonatum biflorum Ell.; A. Gray, Manual, Ed. 2, 466. 1856.

Salomonia biflora Farwell, Rep. Com. Parks Detroit **11**: 53. 1900.

Polygonatum boreale Greene, Leaflets **1**: 181. 1906. Farwell, Bull. Torrey Club **42**: 253. *pl. 14A*. 1915.

Known from Massachusetts south to Carolina and west to Wisconsin, Michigan and Indiana. The bounds probably extend beyond these limits.

MASSACHUSETTS: Oak Island, May 23, 1897, *J. M. Greenman 2284;* Stony Brook, May 15, 1897, *J. M. Greenman 2288;* Provincetown, May 22, 1904, *J. M. Greenman 3013*. CONNECTICUT: Norwich, May 25, 1883, *W. A. Setchell* (Cal.); Waterbury, June 1, 1888, *Constance G. Dubois* (Cal.). NEW JERSEY: Greenwood Lake, Passaic County, May 19, 1907, *K. K. Mackenzie 2574;* Somerset County, *R. C. Perry.* PENNSYLVANIA: Mountville, May, 1889, *A. F. Eby.* VIRGINIA: Hungry Hollow, northeast of Marion, Smyth County, May 24, 1892, *John K. Small* (Cal.). INDIANA: Harrison Township (Section 30), Wells County, May 14, 1905, *Charles C. Deam* (specimen verging toward var. *cuneatum*); North Lapaz Junction, Marshall County, May 18, 1913, *J. A. Nieuwland 11035.* WISCONSIN: Ephraim, June 5, 1907, *J. M. Greenman 2167;* Appleton, May 15, 1896, *H. P. Chandler* (Cal.). MINNESOTA: Minneapolis, June, 1890, *J. H. Sandberg.*

Farwell has endeavored to separate *P. boreale* Greene from *P. pubescens* on the basis of the somewhat larger and more elliptical leaves of the former, but the variation between them is apparently continuous. Moreover, the two specimens cited above from Greenwood Lake, New Jersey, and Ephraim, Wisconsin, are exactly alike and correspond with the measurements given by Farwell for *P. boreale.* Hence, in the presence of intermediates, both cannot be recognized since they have the same range.

1a. POLYGONATUM PUBESCENS CUNEATUM (Greene) Farwell

Polygonatum cuneatum Greene, Leaflets 1: 181. 1906.

Polygonatum pubescens cuneatum Farwell, Bull. Torrey Club **42**: 253. *pl. 13, B.* 1915.

Described by Greene from near Turin, Marquette County, Michigan. According to Farwell it differs from *P. pubescens* only in having longer and relatively narrower leaves cuneate at the base. Known from Michigan to Pennsylvania and Connecticut.

CONNECTICUT: Berlin, 1870, *T. S. Brandegee* (Cal. *119680*). PENNSYLVANIA: Bellwood, Blair County, May 18, 1904, *O. E. Jennings* (Cal. *69244*). In these two specimens the leaves are 20–25 mm. wide × 6–9 cm. long, the flowers small, greenish, 8–10 mm. long.

1b. **Polygonatum pubescens australe** (Farwell) comb. nov.

Polygonatum boreale australe Farwell, Bull. Torrey Club **42**: 254. *pl. 14, B.* 1915.

Known only from Detroit, Michigan, and the following locality:

MASSACHUSETTS: Purgatory Swamp, Westwood, May 14, 1904, *A. H. Moore* (Cal. *158495*). The specimen here cited and photographed (PLATE 4, A) agrees with Farwell's description except that the peduncles are mostly two-flowered. This form is decidedly smaller and more slender than var. *cuneatum*, but may perhaps be connected with it by intermediates. The dimensions of the specimens studied are as follows: stem 1.5–2.5 mm. in diameter, rootstock 4–5 mm. in diameter, leaves pubescent and glaucous below, elliptical, 4.5–6 cm. long, 14–22 mm. wide.

2. POLYGONATUM HIRTUM (Bosc) Pursh

Convallaria hirta Bosc; Poiret, Encyc. 4: 369. 1796.
Polygonatum hirtum Pursh, Fl. Am. Sept. 234. 1814.

This species is unknown at the present time, but there should be no difficulty in identifying it from Poiret's description and the specimens in Paris. It is evidently most nearly related to *P. pubescens*, with which it agrees in having pubescence along the nerves on the ventral surface of the leaves, but from which it differs in that the stem and peduncles are also pubescent. The leaves are described as sessile, nearly amplexicaul, oval, large, ending in a long, obtuse point. The peduncles are said to be an inch long and two- or three-flowered. The size of the flowers can only be determined by examination of the specimens at the Museum d'Histoire Naturelle in Paris. Crevecoeur brought the species from North America to the Jardin des Plantes in 1789.

3. POLYGONATUM BIFLORUM (Walt.) Ell.

Convallaria biflora Walt. Fl. Car. 122. 1788.
Polygonatum angustifolium Pursh, Fl. Am. Sept. 234. 1814.
Polygonatum biflorum Ell. Bot. S. C. & Ga. 1: 393. 1817.
Convallaria angustifolia Schult. Syst. 7: 301. 1829.
Polygonatum multiflorum β americanum Hook. Fl. Bor. Am. 2: 176. 1840 (in part).

Carolina to Pennsylvania.

This species occurs on the Atlantic coast, but its full range is at present unknown. Since the second edition of Gray's Manual, in which *P. pubescens* and other forms were merged with it, *P. biflorum* has been an inclusive species, supposed to range northward to New Brunswick and westward to Kansas and Texas. The precise characters of Walter's *P. biflorum* are difficult of determination. Farwell (*l. c., pl. 15, A*) published a figure of what he believed to be the type of the species, from a specimen collected in Franklin, New Jersey, by H. H. Rusby. I have examined specimens the exact counterpart of this. It is a fairly constant form and I have described it below as *P. biflorum hebetifolium*. It cannot represent Walter's type because that calls for a three-nerved leaf.

What I believe to be the type of Walter's *Convallaria biflora* is represented by a suite of six sheets of specimens, all very uniform, from the Chapman herbarium in the herbarium of the Missouri Botanical Garden. Unfortunately these are without locality, but they doubtless came from somewhere in the southeastern states, probably North Carolina. One of the sheets is represented in PLATE 4, B, and a description of the specimens follows:

Plant glabrous, 2–5 dm. high, naked portion of stem usually shorter than leafy portion. Leaves seven to ten, secund, narrowly elliptic-lanceolate, tapering gradually to a long, narrow point, more acute than in any other American *Polygonatum*, 7–12 cm. long, 8–17 mm. wide, with three to seven more or less prominent nerves, tapering gradually to a semiamplexicaul or sessile base. Peduncles slender (less than 0.5 mm. in diameter) 2–3 cm. in length, bearing one or two flowers on short pedicels 4–6 mm. in length. Flowers yellowish, about 2 cm. long and 3–5 mm. in diameter.

A specimen collected by *C. W. Eisenhower* at Conewago Creek, Pennsylvania, in May, 1898, agrees with the type except that it has somewhat broader leaves (15–21 mm. wide).

3a. **Polygonatum biflorum hebetifolium** var. nov.

A specie differt foliis latioribus et obtusioribus (7–10 cm. longis, 13–26 mm. latis), sine nervis manifestis aut solum nervo medio indicato; floribus minoribus, albidis (7–15 mm. longis), frequenter binis, pedicellis usque ad 1 cm. longis.

NEW YORK: Princes Bay, Staten Island, May 25, 1889, *N. L. Britton* (Cal.). NEW JERSEY: Snake Hill, near Hoboken, June 2, 1884, *H. von Schrenk*. PENNSYLVANIA: Mountville, July, 1888, *A. F. Eby;* Mt. Alto, 1909, *Joseph Illick* (flowers 14 mm. long); York County, June 3, 1895, *N. M. Glatfelder* (no flowers);

York County, June 3, 1895, *S. Williams* (no flowers). DISTRICT OF COLUMBIA: Washington, 188–, *L. F. Ward* (Cal.). KENTUCKY: Louisville, 1835, *C. W. Short* (flowers 15 mm. long); Bowling Green, May 29, 1899, *Sadie F. Price*. NORTH CAROLINA: locality, date, and collector's name unknown (specimen in the Chapman herbarium, type). MISSOURI: Watson, June 1, 1894, *B. F. Bush 527*.

One sheet in the Chapman herbarium contains one specimen of typical *P. biflorum* and one of the variety (PLATE 5, A). Hence no doubt they both occur in the same locality. The variety extends as far west as Missouri and its flowers vary somewhat in size, the leaves also showing some variation in relative width and in obtuseness. Indeed I have included a considerable range of forms which may ultimately have to be separated. While in the type specimen the flowers are small and the leaves scattered on the stem, in the Missouri form (PLATE 5, B) the flowers are much larger (18 mm.) and the leaves rather crowded on the stem. A majority of the specimens cited correspond rather more nearly with the latter condition than with the former.

4. POLYGONATUM CANALICULATUM (Muhl.) Pursh

Convallaria canaliculata Muhl.; Willdenow, Hort. Berol. 45. 1805.
Polygonatum canaliculatum Pursh, Fl. Am. Sept. 234. 1814.

This North American species was described as follows:

> Foliis alternis amplexicaulibus oblongis margine pubescentibus, caule canaliculato, pedunculis bifloris axillaribus. Differt a Convallaria pubescenti; foliis oblongis glabris margine tantum tenuissine pubescentibus, corolla magnitudine et facie Convallariae Polygonati.

C. multiflora Michx. (Fl. Bor. Am. 1: 202. 1805) is given as a synonym, from which it may be inferred that the distribution "Pennsylvania to Virginia" given by Michaux applies to *P. canaliculatum*. Although the name *P. canaliculatum* has since been used in various senses, yet the pubescent leaf-margins prevent its identification with any species at present known. Its exact characters should be determined from the original specimens and the careful description given by Schultes (Syst. 7: 1670. 1830).

5. POLYGONATUM COMMUTATUM (J. A. & J. H. Schult.) Dietr.

Convallaria commutatum J. A. & J. H. Schult. Syst. 7: 1671. 1830.

Polygonatum commutatum Dietr.; Otto & Dietr. Gartenz. 3: 223. 1835.

Polygonatum multiflorum β americanum Hook. Fl. Bor. Am. 2: 176. 1840 (in part).

Polygonatum latifolium var. *commutatum* Baker, Jour. Linn. Soc. Bot. 14: 555. 1875.

Polygonatum biflorum commutatum Morong, Mem. Torrey Club 5: 115. 1894.

Salomonia commutata Britton, Man. 273. 1901.

Georgia to Pennsylvania, Wisconsin, South Dakota and Oklahoma, probably extending north into Canada.

This appears to be the most widely distributed of all the species. It varies considerably within the range indicated, and other segregates may be detached from it later. The following specimens in the herbarium of the Missouri Botanical Garden are here referred to it:

PENNSYLVANIA: Conewago, May, 1889, *J. H. Eby;* George School woods, June 2, 1906, *Elma M. Eves.* GEORGIA: cliffs of the Coosa River, Rome, 1872, *A. W. Chapman 3886, 3917.* TENNESSEE: Knoxville, April and May, 1898, *Albert Ruth 148,* 781 (the latter specimen intermediate between *P. commutatum* and *P. biflorum hebetifolium,* leaves 38 × 12 cm.). WISCONSIN: Mirror Lake, Sauck County, July 13, 1903, *H. Eggert.* IOWA: Iowa City, *A. S. Hitchcock.* MISSOURI: St. Louis, June, 1892, *H. Eggert;* Ilasco, August 20, 1911, *John Davis 987.* SOUTH DAKOTA: Vermillion, May 22, 1911, *S. S. Vischer 4018;* Oakwood, *Thomas A. Williams;* Oakwood, May 23, 1902, *A. G. Johnson.* NEBRASKA: Nuckolls County, August, 1899, *George C. Hedgcock* (three sheets); southwest of Lincoln, June 5, 1900, *George C. Hedgcock;* South Bend, May 12, 1900, *George C. Hedgcock.* KANSAS: Cowley County, June, 1898, *Mark White;* Riley County, 1896, *J. B. Norton 834;* Fort Riley, Geary County, July 2, 1895, *C. H. Thompson.* OKLAHOMA: Sapulpa, July 27, 1894, *B. F. Bush 578* ("uncommon").

5*a*. **Polygonatum commutatum virginicum** (Greene) comb. nov.

Polygonatum virginicum Greene, Leaflets 1: 181. 1906.

Polygonatum biflorum virginicum Farwell, Bull. Torrey Club 42: 254. *pl. 15, B.* 1915.

This variety (PLATE 6, A) is evidently closely related to the typical form of *P. commutatum*, from which it differs chiefly in having elliptical leaves, not amplexicaul, dark green in color, and more slender peduncles. Farwell's illustration represents a form of *P. commutatum*.

VIRGINIA: bluffs of the middle fork of the Holston River, near Marion, Smyth County, May 22, 1892, *John K. Small* (Cal. *3835*, co-type of *P. virginicum*). DISTRICT OF COLUMBIA: Dalecarlia Reservoir, May 23, 1905, *Joseph H. Painter 1309*.

5*b*. **Polygonatum commutatum ovatum** (Farwell) comb. nov.

Polygonatum biflorum ovatum Farwell, Bull. Torrey Club **42**: 255. *pl. 16, A*. 1915.

Michigan to Iowa, Nebraska and Oklahoma.

This variety as here understood differs from the species chiefly in having leaves which are amplexicaul, usually rather broadly ovate with very blunt tips, peduncles stout and flattened, flowers frequently in 3's and 4's, about 18 mm. in length. It is clearly related to *P. commutatum* rather than *P. biflorum*.

IOWA: Shelby County, May 30, 1894, *T. J. & M. F. L. Fitzpatrick;* Grinnell, 1886, *H. W. Norris*. NEBRASKA: near Lincoln, June 5, 1900, *George C. Hedgcock*. OKLAHOMA: Catoosa, May 14, 1895, *B. F. Bush 1282* ("common").

6. POLYGONATUM GIGANTEUM Dietr.

Polygonatum giganteum Dietr.; Otto & Dietr. Gartenz. **3**: **222**. 1835.

Polygonatum multiflorum β americanum Hook. Fl. Bor. Am. **2**: 176. 1840 (in part).

Polygonatum biflorum γ giganteum Wood. Bot. & Flo. 346. 1870.

Polygonatum canaliculatum giganteum Farwell, Bull. Torrey Club **42**: 256. *pl. 18*. 1915.

Maryland and Pennsylvania to Wisconsin and Montana, south to Nebraska, Missouri and Kentucky.

This species was originally described by Dietrich from specimens received from the Edinburgh Botanic Garden, the superintendent's son having obtained it from North America. It appears to be essentially a giant derivative of *P. commutatum*, yet its characters are sufficiently distinct to be amply worthy of specific rank. The following specimens, while conforming in general to Dietrich's description, vary somewhat in leaf-shape, length of peduncles, number of flowers, etc., sometimes much exceeding the measurements of the original description. In that description the plants were 3 feet high, though they attained a height of 7½ ft. in the Edinburgh Garden; the peduncles 6–8 lines long, bearing 3–4 flowers on pedicels 4–6 lines long; the leaves oval, glaucous beneath. In the specimens of *P. giganteum* examined, the stem in one case attained a diameter of 2 cm., the (flat) peduncles a length of 11 cm. (bearing as many as nine flowers), the leaves a size of 19 × 10 cm. Most of the specimens were, however, much smaller, though usually larger and with more numerous pedicels than in Dietrich's material. Farwell's specimens (*pl. 18*) from Michigan have smaller flowers (14–16 mm.).

Pennsylvania: Crum Creek near Philadelphia, June 7, 1870, *J. H. Redfield 8187*. District of Columbia: Washington, June 12, 1878, *J. W. Chickering, Jr.* Ohio: Springfield, *M. G. Williams*. Illinois: woody bluffs southeast of East Carondelet, September 4, 1891, *E. Douglas*. Wisconsin: Racine, September 11, 1879, *J. J. Davis;* Kilbourn, August 15, 1892, *Mrs. Wallace* (leaves 14 × 7.5 cm., broadly elliptical, very obtuse). Kentucky; Bowling Green, June, 1899, *Sadie F. Price*. Missouri: Woodlawn, September 19, 1878, *G. Engelmann;* Hannibal, May, 1906, *John Davis 12001;* St. Louis, July or August, 1891, collector unnamed. Nebraska: Sargent's Hill, June, 1853, *F. V. Hayden;* St. Helena, *T. A. Bruhin;* Lincoln, August, 1889, *H. J. Webber*. Also the following: "A. A. M.," June, 1858 (Herb. Fritchey); "from Niobrarah River to Fort Pierre, June, 1859, *F. V. Hayden* (Reynold's Expedition to the headwaters of the Missouri and Yellowstone Rivers).

7. POLYGONATUM PARVIFLORUM (Poir.) Dietr.

Convallaria parviflora Poir. Encyc. Suppl. **4**: 29. 1816.

Polygonatum parviflorum Dietr.; Otto & Dietr. Gartenz. **3**: 222. 1835.

This species is unidentified. Its description is as follows:

C. foliis subsessilibus, ovato-oblongis, glabris; pedunculis axillaribus bi-raro trifloris minimis.

The flowers are further said to be small, white, half as large as in *C. Polygonatum*. The exact features of this plant can only be determined by examination of the original specimen in the Desfontaine herbarium, in Paris.

8. **Polygonatum cobrensis** (Wooton & Standley) comb. nov.

Salomonia cobrensis Wooton & Standley, Contrib. U. S. Nat. Herb. **16**: 113. 1913.

New Mexico.

Through the kindness of Mr. William R. Maxon of the National Herbarium I have been able to examine the type specimen, which came from Copper Mines, Santa Rita, New Mexico. The following specimen (PLATE 6, B), in the herbarium of the Missouri Botanical Garden, came from a neighboring locality and shows still better the features of this species: Pinos Altos Mountains, New Mexico, *E. L. Greene*, May 21, 1880. Dr. Greene referred this specimen to the European *P. vulgare* Desf. which it evidently resembles, though I have seen no specimens of the latter which approach it very closely. A critical comparison should be made with European specimens. The species most resembles ***P. biflorum hebetifolium***.

9. POLYGONATUM ELLIPTICUM Farwell

Polygonatum ellipticum Farwell, Bull. Torrey Club **42**: 255. *pl. 16, B.* 1915.

This species was based on material collected by its author at Rochester, Michigan, in June, 1914. Since I have seen no specimens I am unable to judge of its status.

Explanation of plates 4–6

PLATE 4

A. *Polygonatum pubescens australe* (Farwell) Gates. Photograph of a specimen from Purgatory Swamp, Westwood, Massachusetts, *A. H. Moore*. B. *Polygonatum biflorum* (Walt.) Ell. Photograph of a specimen in the Chapman herbarium, presumably representing the type of *Convallaria biflora* Walt.

PLATE 5

Polygonatum biflorum hebetifolium Gates. A. Photograph of a type specimen. B. Photograph of a specimen from Watson, Missouri, *B. F. Bush 527*.

PLATE 6

A. *Polygonatum commutatum virginicum* (Greene) Gates. Photograph of a co-type specimen of *P. virginicum* Greene. B. *Polygonatum cobrensis* (Wooton & Standley) Gates. Photograph of a specimen collected in the Pinos Altos Mountains, New Mexico, *E. L. Greene*.

Some factors influencing the prevalence of Endothia gyrosa

NEIL E. STEVENS

(WITH FIVE TEXT FIGURES)

INTRODUCTION

The distribution of the American species of *Endothia* does not coincide with that of their hosts. Range maps of these species made by Dr. C. L. Shear and the writer as the result of two years collecting, show that *Endothia gyrosa* (Schw.) Fries is abundant in the Southeastern States and has been found occasionally as far north as southern Connecticut and western New York, while two of its hosts, *Fagus* and *Quercus*, occur several hundred miles further north. *Endothia fluens* (Sow.) S. & S., which is common on *Castanea* and *Quercus* from northern Alabama to southern Pennsylvania, has not yet been found north of this region. The territory between Virginia and southern New England appears then to be a transition region for these fungi. Examination of these maps also shows that *Endothia singularis* (H. & P. Syd.) S. & S. and *E. fluens* occupy fairly well defined climatic areas and are apparently not found in America outside these areas. *Endothia gyrosa*, however, while abundant only in the Southeastern States, has been found in Connecticut, New York, Kansas, Texas, and on the Pacific Coast.

The present paper deals with *Endothia gyrosa*, which has a much wider known range in America than any other species of the genus. This fungus is undoubtedly indigenous, having first been collected by Schweinitz at Salem, North Carolina, nearly a century ago, and previous to recent work had been collected at various times in the following widely separated localities: Indiana, 1831 (?), *Schweinitz;* Texas, 1869, *Ravenel;* New York, 1872, *G. W. Clinton;* Florida, 1886–87, *Calkins;* Mississippi, 1887, *Earle;* Kansas, 1887, *Swingle;* Louisiana, 1887, *Langlois;* New Jersey, 1892 (?), *Ellis*.

The intensive collecting of the last few years has not greatly extended the range of *Endothia gyrosa* beyond that known twenty-five years ago. It may therefore be fairly assumed that this fungus has reached its natural limits of distribution in this country and that the present range is determined by environmental factors, in contrast to fungi which have been recently introduced and have therefore not yet spread throughout the region suitable for their development.

In collaboration with Dr. Shear the writer has prepared a map (FIG. 1), which gives a somewhat more accurate idea of the distribution of *Endothia gyrosa* than that previously published. The cross hatching indicates the area in which the fungus is known to be abundant, the dots outside that region indicate localities in which the fungus has been collected. In considering the distribution of *E. gyrosa* the problem is double, for the fungus has been found at widely separated localities hundreds of miles outside the region in which it is common. Conditions under which it can exist are not then, necessarily, those under which it will become abundant. The conditions which limit the occurrence

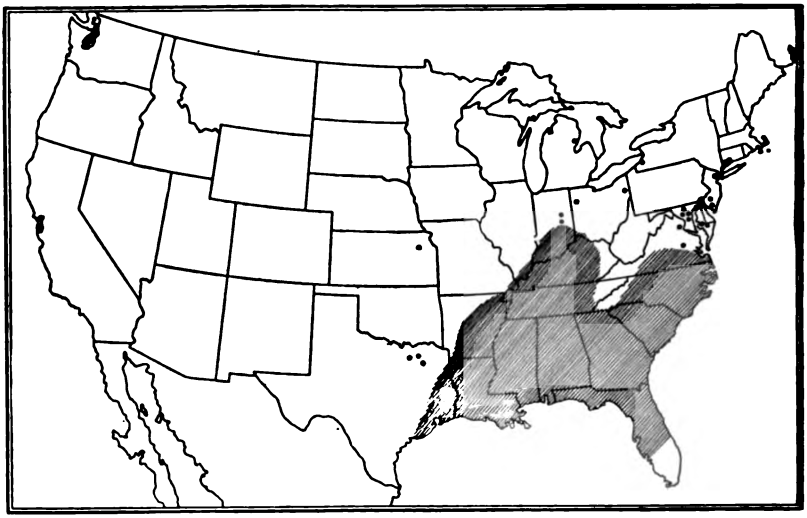

FIG. 1. Known distribution of *Endothia gyrosa*. Cross hatching indicates area in which the fungus is known to be abundant. Dots indicate localities where it has been collected. Map prepared by the writer in collaboration with Dr. C. L. Shear.

of this fungus have not yet been discovered. The following notes indicate certain factors which seem to influence its prevalence within its present range. In discussing this question observations are confined to the eastern half of the United States, where most of the collecting was done and where, consequently, the distribution of the species is fairly accurately known. This area is particularly favorable for a study of the climatic relations of fungi since, as Ward (11) has pointed out, it constitutes a single climatic subdivision of the country.

INOCULATION EXPERIMENTS

In connection with work already reported (10), inoculations of *E. gyrosa*, *E. fluens* and *E. fluens mississippiensis* were made at various points from Charlottesville, Virginia, to Concord, New Hampshire, in the hope that data might be obtained concerning the effect of climate on their growth. The inoculations were located at points chosen for their availability and their nearness to United States Weather Bureau Stations. These places were visited every five or six weeks during the summer of 1914, twice during the summer of 1915, and once in May, 1916. At each visit ten or more new inoculations were made on species of *Quercus* (sometimes also on *Fagus*) using the method described for previous work (8, 10), and notes were made on the condition of the earlier inoculations. TABLE I gives a brief summary of the results of the observations on *E. gyrosa*.

The results of these inoculations have emphasized four facts, already known. Black oaks (*Erythrobalanus* Spach.) are much more favorable for the growth of *E. gyrosa* than white oaks (*Lepidobalanus* Endl.). *E. gyrosa* will under certain conditions grow and winter over as well near or beyond the northeast limits of its known range as it will within the region where it is most abundant. Water supply is important in the growth of the fungus. The condition of the host is important; this may be, at least in part, only another indication of the importance of the water supply, as obviously the water necessary for growth may be supplied by the host or by the atmosphere.

An examination of the table shows that *Endothia gyrosa* survived the winters of 1914–1915 and 1915–1916 without apparent

TABLE I

Locality	Inoculations made	Pycnidial stromata appeared	Further notes
Charlottesville, Va.	April 20 and May 21, 1914.	Oct. 2, 1914. Abundant especially on tree inoculated May, 1914.	The small tree on which the inoculations of May 1914 were made died during the summer from partial girdling at the time of inoculation. Apparently as a result of this the fungus developed rapidly and produced pycnidial stromata for a distance of 10–12 in. above the point of inoculation.
Fairfax, Va.	April 21 and Aug. 1, 1914.	July, 1914, a few pycnidia on the injured tissue above the inoculations of April. Oct. 24, 1914, fairly abundant and well developed on inoculations of both dates.	
Frederick, Md.	May 30, 1914.	May 21, 1915.	There was no evidence of growth from these inoculations during the summer of 1914. Pycnidia, however, appeared on one branch in the spring of 1915.
Woodstock, Md.	May 30 and July 30, 1914.	Oct. 19, 1914.	While both these inoculations showed considerable development of pycnidial stromata they were less than some others both further north and further south.
Wilmington, Del.	July 6, 1914.	Oct. 6, 1914.	Large well-developed stromata, which showed no change during the succeeding summer.
Hartford, Conn.	July 15, 1914. Sep. 24, 1914.	Sept. 23, 1914. A very few stromata. Aug. 18, 1915, large well-developed stromata.	In this case stromata developed abundantly during the summer of 1915 from inoculations which during the summer of 1914 showed only a few scattering stromata.
Amherst, Mass.	July 15, 1914.	Sept. 24, 1914.	This inoculation became contaminated later with *Endothia parasitica*.
Williamstown, Mass.	July 14, Sept. 24, 1914, & May 21, 1915.	Aug. 16, 1915.	The small oak on which the inoculations of July 1914 were made was killed by the cuts and bore numerous large pycnidia of this fungus during the summer of 1915. None of the inoculations made at this point produced stromata during the summer of 1914.

TABLE I—*Continued*

Locality		Inoculations made	Pycnidial stromata appeared	Further notes
Concord, N. H.		Sept. 22, 1914 May 18, 1915.	Aug. 19, 1915.	Several good sized pycnidial stromata developed on several of the inoculations of both these dates.
Stations on Overlook Mt., Woodstock, N. Y.				
Station	Elevation in feet			
S 3	1,000	June 12, 1914.	Aug. 14, 1915.	Pycnidial stromata appeared from one inoculation during the summer of 1915, though there had been no evidence of development during the summer of 1914.
C	1,500	June 13 & Sep. 30, 1914.	Aug. 11, 1915.	Abundant large pycnidial stromata developed during the summer of 1915, although none had developed during the summer of 1914.
O 6	1,500	June 11, Jul. 8, Aug. 12, 1914.	May 25, 1915. From inoculations of June, 1914; and Aug. 12, 1915, from inoculations of July and Aug. 1914.	
O 1	1,900	June 11, 1914. July 9, 1914.	Sept. 29, 1914.	These showed the greatest development of any stromata of *E. gyrosa* in the entire series of inoculations. Abundant pycnidial stromata developed extending 1–6 in. above and below the cut in each inoculation There was continued growth but no perithecia had developed up to May 1916.
O 4	2,800	July 9, 1914.	May 26, 1915.	Numerous stromata developed well beyond the cut and extending for a foot or more above and below the place of inoculation. These were alive and in good condition May 1916, but had produced no perithecia.

All the inoculations listed above as having developed pycnidial stromata were alive in May, 1916, but no perithecia had developed.

injury in the most northern localities at which inoculations were made, i. e., Williamstown, Massachusetts, and Concord, New Hampshire, and at an elevation of 2,800 feet on Overlook Mountain. Its growth in these localities was nearly, if not quite, equal to that at more southern points.

The effect of abundant moisture is readily seen from the fact that at Concord, Williamstown, and two stations, S 3 and C, on Overlook Mountain, stromata developed in 1915 from inoculations which had shown no growth in 1914; as well as by the fact that at Hartford, Connecticut, stromata developed abundantly during the summer of 1915 from inoculations which during the summer of 1914 showed only a few scattered stromata. As the weather conditions of the two summers in these localities have been discussed in detail by the writer elsewhere (10) it may merely be stated here that there was little difference in the temperature but that the rainfall of 1914 was much below normal; that of 1915 well above normal.

The importance of the condition of the host in the growth of *Endothia gyrosa* was best seen at Charlottesville, Virginia,* where the small tree which was inoculated gradually died from the effect of the cuts and the fungus developed rapidly and produced stromata for a considerable distance above and below the point of inoculation. The growth of the fungus on this tree was much greater than that on any of the trees which survived the wounds made by inoculations. The peculiar relations between this fungus and its host have been referred to elsewhere (8). In general it has been observed that tissue injured by cuts or bruises in such a way that it does not dry out immediately but remains in a living condition for some time is the most favorable place for the development of this fungus. Such a condition is found on the stubs of cut limbs, on bruised or broken trunks, and especially on exposed roots which have been injured by tramping of cattle or by other means. This habit of the fungus seems to materially affect its distribution.

CLIMATIC RELATIONS

Temperature.—The range of temperature favorable for the growth of *E. gyrosa* in artificial media seems to be almost identical with that of *E. parasitica* (8). The writer has recently demonstrated (10) that during the years ending in May and August,

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* The inoculations and some of the observations at this point were made by G. F. Gravatt.

1915, *Endothia parasitica* made almost twice the lateral growth on *Castanea dentata* in Virginia that it made in New England. This difference in growth is closely correlated with the difference in temperature of the two regions. It seems very probable, therefore, that the more favorable temperature of the Southern States favors the more abundant growth of *E. gyrosa* in that region.

A comparison of the map (FIG. 1) of the distribution of *E. gyrosa* with climatic maps shows certain general correlations. Much of the region where *E. gyrosa* is most abundant lies south of the isotherm of 6,000 temperature summation and the closely similar isotherm of 600 temperature efficiency as calculated by the Livingstons (7). Much of the region where *E. gyrosa* is most abundant lies within or south of the area of eight months (April to November) vegetation, as mapped by Zon (12).

It is significant, however, that the area in which *E. gyrosa* is abundant does not agree closely with any of these lines. The fungus is abundant considerably north of the line of 600 temperature efficiency in Kentucky and southern Indiana but falls far short of this isotherm in eastern Virginia. The same relation exists between the area in which *E. gyrosa* is abundant and the isotherm 10,000 as given by Livingston (6) in his chart based on physiological summation indices of temperature efficiency for plant growth (6, *f*. *2*). Similarly, the northern limit of the area of abundance coincides closely with the limit of eight months vegetation in Virginia, but runs well toward the middle of the area of seven months vegetation in Kentucky and Indiana. Moreover, as has been stated above, the temperature of New England in the region of six months vegetation is evidently sufficient for the growth of *E. gyrosa* under some circumstances.

On the other hand, *Endothia gyrosa* is not perceptibly more abundant in the areas of nine to twelve months vegetation, i. e., southern Mississippi, Alabama, and Florida, than it is in certain portions of the area of seven months vegetation, i. e., Kentucky and southern Indiana. It would seem then that temperature alone is not very significant in determining the abundance of this fungus.

Precipitation.—One of the most important climatic factors influencing the abundance of *E. gyrosa* in the Southern States is probably the greater rainfall, especially during the growing season. The rainfall of the eastern United States during the growing season is given by Henry (5). In general, the area where *E. gyrosa* is abundant is largely in or south of the region of twenty-five inches rainfall, April to September, inclusive. An exception to this is found in Tennessee, Kentucky and southern Indiana, which are well outside the area of twenty-five inches rainfall, but where *E. gyrosa* is fully as abundant as in the region of over thirty inches rainfall.

The striking fact has recently been pointed out by Ward (11), that in the eastern United States no sudden changes in climate are met with in going from north to south, but the transitions are everywhere slow and gradual. On the other hand, there is a fairly definite line of demarcation between the area in which *E. gyrosa* is abundant and the area where it is rare. This seems to indicate that factors other than temperature and rainfall markedly affect the prevalence of this fungus.

That *E. gyrosa* is abundant in southern Indiana where the climate is both drier and cooler than in most regions where the fungus is commonly found, seems to be due to greater opportunity for infection. As has been pointed out in an earlier paper (8), southern Indiana is a stock-raising region where pastures containing beech trees are numerous. Nearly all of the collections of *E. gyrosa* in this region were found in such pastures on the roots of beech which had been injured by cattle. The importance of such opportunity for infection is emphasized by the condition found at Columbiana, Ohio, in June, 1913. This locality is several hundred miles outside the area in which *E. gyrosa* is commonly found in abundance, yet in a single pasture where there were from fifteen to twenty large beech trees many of whose roots were exposed and had been injured by trampling of cattle, the writer found this fungus abundant in more than twenty small patches.

OPPORTUNITY FOR INFECTION

Field observations have convinced the writer that opportunity for the infection of its hosts is of the greatest importance in determining the prevalence of *E. gyrosa* and that the greater abundance of *E. gyrosa* in the southern states is largely accounted for by the greater opportunity for infection in that region, aided by more favorable temperature and more abundant rainfall. Other things being equal, the more frequent the occurrence of places favorable for its growth the more abundant a fungus will become. This process is cumulative, for the more prevalent a fungus the more completely it will occupy the available places of infection.

Greater opportunity for infection in the south is due to the greater number of host species and to the greater importance of these species relative to other trees. And especially to greater opportunity for the infection of individual hosts from injuries due to different climatic, soil and cultural conditions.

HOST RELATIONS

Endothia gyrosa is found commonly in the United States on hosts of four genera: *Castanea*, *Fagus*, *Liquidambar*, and *Quercus*—least abundantly on *Castanea*, most abundantly on *Quercus*—the collections made in the work already referred to (8) being in the following numbers: *Castanea*, 18; *Fagus*, 47; *Liquidambar*, 49; *Quercus*, 158. Actually the fungus is much less frequent on *Castanea* than is indicated by these figures, since the eighteen collections represent all the cases in which *E. gyrosa* was found on *Castanea*, while the number of collections on the other hosts represent simply a few specimens from each locality visited and could have been increased many times.

Endothia gyrosa has been collected by Dr. Shear and the writer on the following species of *Quercus*: *Q. alba* L., *Q. coccinea* Muench., *Q. digitata* (Marsh.) Sudworth, *Q. georgiana* Curtis, *Q. imbricaria* Michx., *Q. marilandica* Muench., *Q. nigra* L., *Q. phellos* L., *Q. Prinus* L., *Q. rubra* L., *Q. velutina* Lam., *Q. virginiana* Mill. From the first, however, it was obvious that the fungus was more abundant on the various species of black oaks than on the species belonging to the white oak section of the genus. Of the 158 specimens from all parts of the United States which were collected, eighty are known to be on species of black oak, nineteen on species of white oak. The specimens, for which the host species is not given, are apparently divided in about the same ratio. These unidentified specimens are chiefly from the southern states where the collecting was done largely in midwinter.

RANGES OF HOST SPECIES

The maps, FIGS. 2–4, show the ranges of the various host species: FIG. 2, the ranges of *Castanea*, *Liquidambar* and *Fagus*; FIGS. 3 and 4, the ranges of the species of *Quercus* on which *E. gyrosa* is known to occur. A comparison of the range maps shows that certain of the host species, i. e., *Castanea dentata*, *Fagus grandifolia*, *Quercus alba*, *Q. coccinea*, *Q. falcata*, *Q. Prinus*, *Q.*

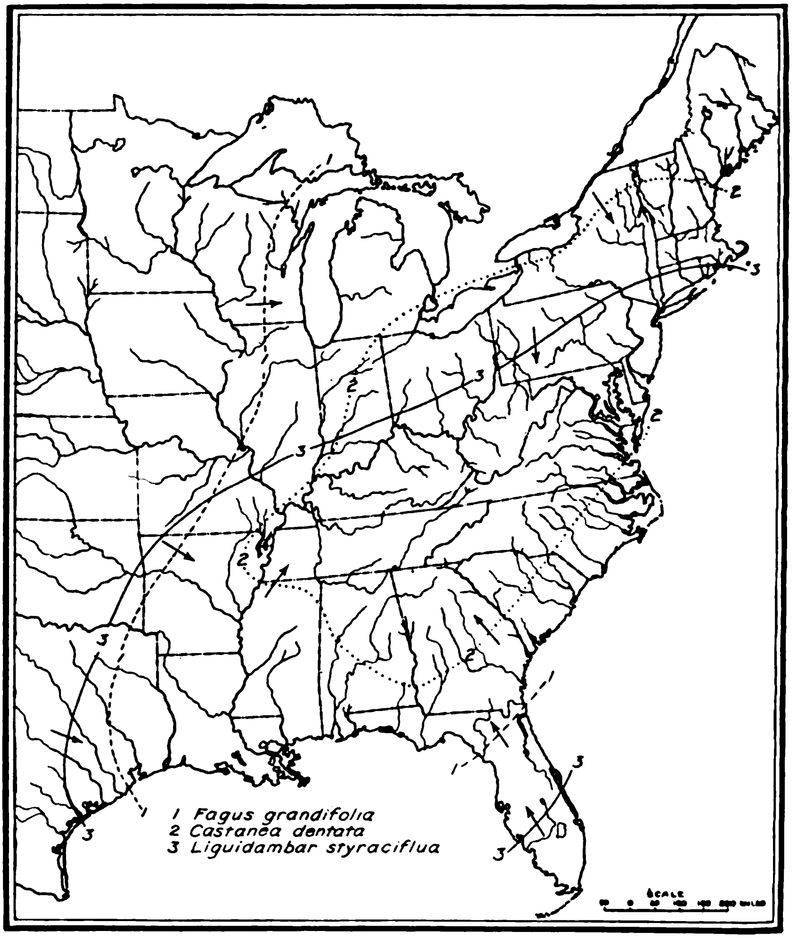

FIG. 2. Ranges of *Fagus grandifolia*, *Castanea dentata*, and *Liquidambar Styraciflua* in the United States. Map prepared by W. H. Lamb, United States Forest Service.

rubra, and *Q. velutina*, extend well beyond the known range of *E. gyrosa*.

In considering the prevalence of a fungus, however, not only the occurrence of its hosts, but their relative abundance must be considered. In general, a fungus will be more abundant in a given locality the more numerous are the favorable hosts. The fact is generally recognized in horticultural practice that an isolated plantation is more likely to escape disease than one close to other similar plantations. It is to be expected then that *E. gyrosa* would be found most abundantly where its favorite hosts are most numerous, and this is actually the case.

FOREST REGIONS

A glance at the map of the forest regions of the United States issued by the Forest Service shows that the region in which *E. gyrosa* is most abundant comprises the southern forest and portions of the central forest. The following brief descriptions of the three forest regions under consideration are taken from the Forest Service map of the "Forest Region of the United States," issued in 1910:

Northern forest (northern portion): White, red and jack pines, spruces, firs (balsam), poplars and aspens, birches, tamarack.

(Southeastern portion): Maples, beech, birches, aspen, chestnut, white, red, and scrub pines, spruces, fir (balsam), hemlocks, tamarack, arbor-vitae.

Central forest. White, black and red oaks, hickories, chestnut, walnut, and butternut, yellow poplar, cherry, ashes, elms, maples, beech, locust, buckeyes, cottonwood.

Southern forest. Yellow pines, white, live, red, and black oaks, hickories, cypresses, white cedar, juniper, red and tupelo gums, magnolias, bays, elms, hollies, ashes.

In both the forest regions in which *E. gyrosa* is abundant, its favorite hosts, white, black and red oaks (*Quercus* spp.), together with beech (*Fagus*), in the central forest, and red gum (*Liquidambar*) in the southern, are included among the characteristic species.

In the northern forest beech is the only host of *E. gyrosa* mentioned among the characteristic trees, and even beech only in the southern portion. It is evident then that though several

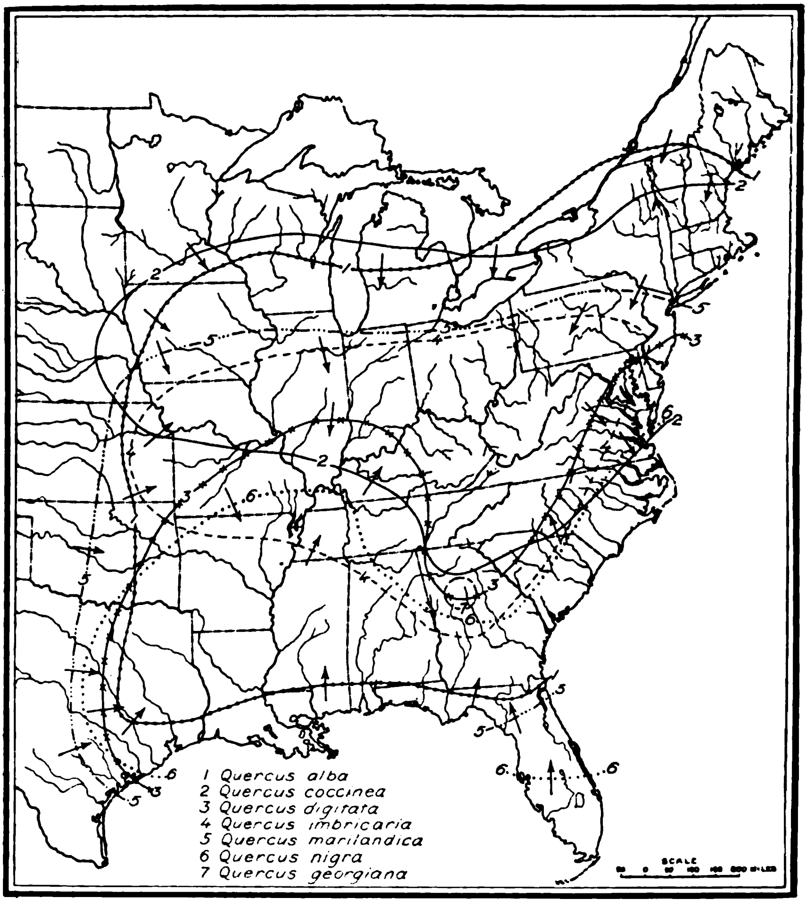

FIG. 3. Ranges of several species of *Quercus* in the United States. Map prepared by W. H. Lamb.

of the host species of *E. gyrosa* extend considerably north of the region where this fungus has been found they no longer predominate.

The relative importance of hosts of *E. gyrosa* among the northern hardwoods is well brought out in a recent report by Frothingham (3, p. 6), in which the species comprising the northern hardwood forest are grouped according to their prevalence as characteristic, locally characteristic, or occasional. Of the hosts of *E. gyrosa* only beech appears among the characteristic and only

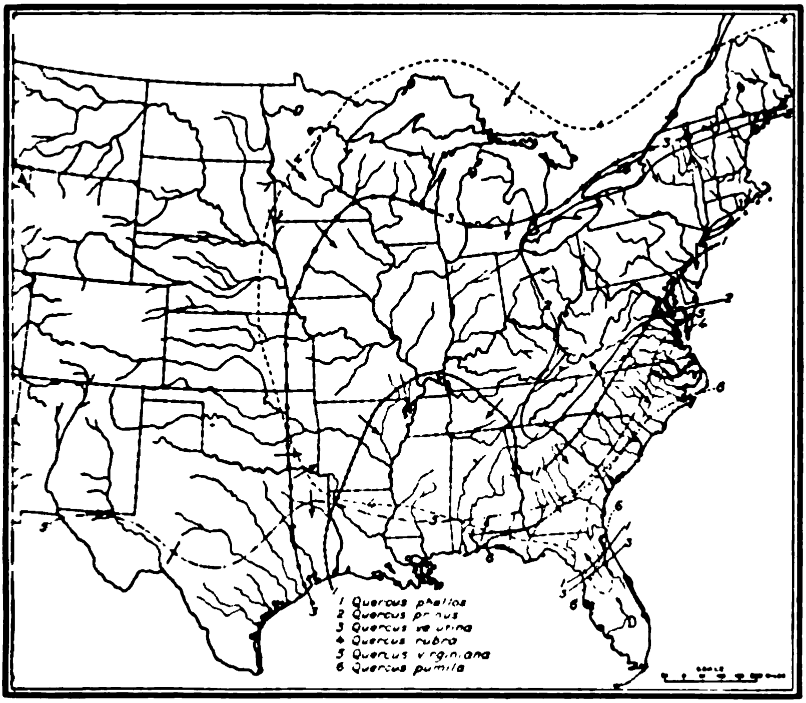

FIG. 4. Ranges of several other species of *Quercus* in the United States. Map prepared by W. H. Lamb.

red oak among the locally characteristic species. It is suggestive that in only one locality, Central Michigan, has *E. gyrosa* been found in the northern forest, especially as that region in New York, Pennsylvania, Maryland, and adjoining portions of West Virginia has been the scene of much recent collecting in connection with work on chestnut blight. There seems to be no climatic reason why *E. gyrosa* should not occur on beech in the northern states of New England, and the writer believes it may yet be found there. Host relations alone would, however, prevent its becoming prevalent.

SOIL RELATIONS

Within the Central and Southern Forest Regions where its hosts are abundant, the relative amount of opportunity for infection is greatly influenced by soil and cultural conditions. As has already been mentioned, exposed and injured roots of *Fagus* and

Quercus are by far the most favorable places for infection of *E. gyrosa*. In the southern states climatic and cultural conditions combine to make such exposed roots very much more common than in the northern states.

EROSION

The difference in soil erosion alone would largely account for the much greater abundance of exposed roots in the south. While no accurate data as to the relative erosion in various parts of the country are at hand, a review of the literature of the subject shows clearly that in the states of Virginia, Kentucky, Tennessee, North and South Carolina, Alabama, Georgia, Louisiana, and Arkansas soil erosion is a serious problem. Davis in a recent review (2) of the subject calls attention to the fact that throughout

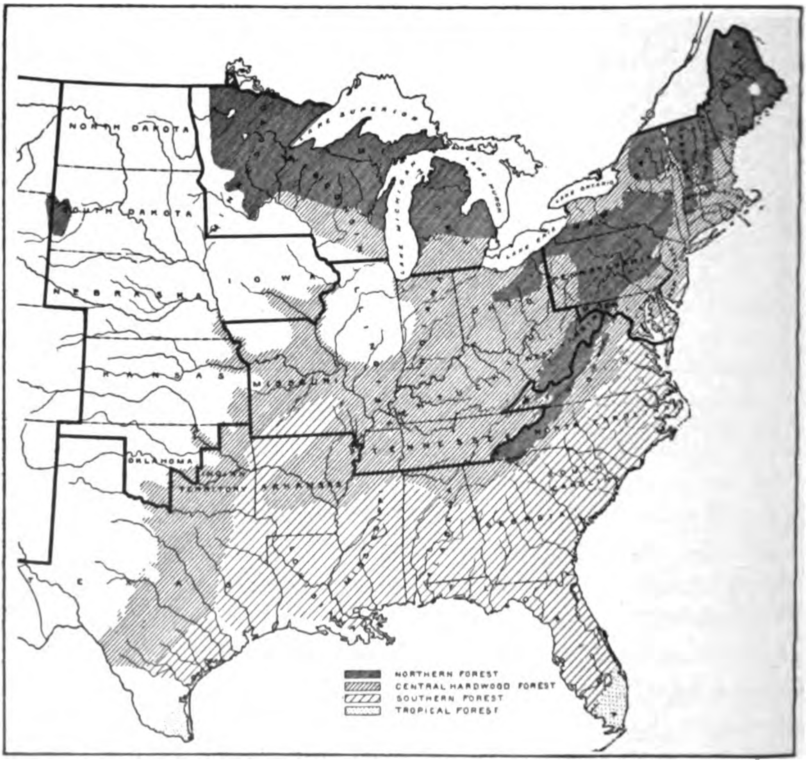

FIG. 5. Forest regions of the eastern United States. Map supplied by United States Forest Service.

the south erosion is worse than in other sections of the country and suggests that "it is probable that the climate has much to do with the fact that erosion is so rapid in the south. The character of the soil makes a marked difference in the rates of erosion under the same climatic conditions."

SNOW-COVER

The abundant rainfall of the southern states, already referred to, no doubt greatly increases erosion. Perhaps equally important is the amount of snowfall, or rather the persistence of snow-cover, since the longer the period during which the ground is covered with snow, the shorter the period of soil erosion.

The snowfall data of the U. S. Weather Bureau are not so arranged as to show readily the period each year for which the ground is covered with snow in any given locality. Recently, however, Brooks published a discussion (1) of the snowfall of the eastern United States in which he reviewed the previous work on the subject and summarized the available data. Brooks also maps the average snowfall for each month, the average annual snowfall in inches, and the average annual number of snowfall days in the eastern United States. From these maps it is possible to get a fairly good idea of the duration of snow-cover in various parts of the region under consideration.

While the total amount of snowfall does not necessarily correspond with duration of snow-cover, in general those regions which have most snow have the longest periods of frozen and snow covered ground, and the shortest periods in which erosion is possible. Certainly soil in the region which has an average of over twenty inches annual snowfall and one inch as early as November is more protected than that south of this region. Longer snow-cover alone would greatly reduce the amount of erosion in the northern states as compared with that in the south. Greater erosion means necessarily more exposed roots and consequently more frequent opportunity for infection with *E. gyrosa*.

CULTURAL CONDITIONS

The contrast between the cultural conditions of the north and south has been frequently noted (4, 9). The relation of cultural conditions to erosion is aptly described by Spillman (9, p. 260) as follows:

> The northern half of the country has always been more or less covered with various grasses. These have prevented soil erosion except in small isolated areas; but in the South where a single-crop system with clean culture has been the rule, and where in consequence, the soils have been left bare during the winter, soil erosion has been an important factor, especially where the land is more or less rolling or hilly.

The effect of the cattle industry in increasing the opportunity for infection and thus in all probability the abundance of the fungus in southern Indiana and Ohio has already been mentioned. And from the beginning of our collecting, the unfenced public squares of the southern towns where stock is permitted to graze have proven most favorable localities for the growth of *Endothia gyrosa*.

In brief, the writer believes that while the occurrence of *E. gyrosa* may be limited by climatic factors which are not yet determined, its prevalence in the southeastern states is caused by the great opportunities for infection in that region, due to the combined influence of host, soil, climatic and cultural conditions.

SUMMARY

Endothia gyrosa, which has a wider known range in America than any other species of the genus, is undoubtedly indigenous, having first been collected by Schweinitz nearly a century ago.

Although found in widely separated localities in the United States it is abundant only in the Southeastern States. Range maps of this and other American species of *Endothia* based on two years' collecting by Dr. C. L. Shear and the writer have already been published.

Inoculation experiments conducted in 1914 and 1915 showed that *E. gyrosa* would under certain conditions grow and winter over beyond the northeastern limits of its known range as well as within the region where it is abundant.

These inoculation experiments emphasized the importance of the water supply and of the condition of the host in the growth of the fungus.

E. gyrosa grows most readily on injured tissue which does not dry out immediately but remains living for some time, such as stubs of cut limbs or injured roots.

The temperature of the Southern States is undoubtedly more favorable for the growth of *E. gyrosa* than that of the states farther north.

The northern boundary of the region where this fungus is abundant does not, however, agree closely with that of any of the temperature regions.

It is not perceptibly more abundant in the areas of nine to twelve months vegetation than it is in areas of seven months vegetation.

Much of the area where *E. gyrosa* is abundant is in or south of the region of 25 inches rainfall, April to September, inclusive. It is, however, very abundant in Tennessee, Kentucky, and Indiana, where the rainfall is less than 25 inches for this period.

Although there are no sudden changes in climate in going from north to south in the eastern United States, there is a fairly definite division into an area where *E. gyrosa* is abundant and an area where it is rare.

This seems to indicate that factors other than climate affect the prevalence of this fungus.

The chief factor in the greater abundance of *E. gyrosa* seems to be increased opportunity for infection.

Opportunity for infection is much greater in the Southern States than in the Northern because of the larger number of host species and their greater importance relative to other species.

Opportunity for infection is still further increased by the soil and cultural conditions which cause greater erosion and leave large numbers of roots of *Fagus* and *Quercus* exposed and subject to injury.

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An annotated list of the forest trees of the Hawaiian Archipelago

VAUGHAN MACCAUGHEY

The following material has been prepared as a compact and convenient check list to the Hawaiian arborescent flora. The forests of the Hawaiian Islands are remarkable for the high percentage of endemic forms. Endemism is indicated in the following list by an asterisk (*) before the name. A second symbol (†) indicates that a species was undoubtedly introduced by the aboriginal Hawaiians from the South Pacific and has become naturalized. The data for each species include the scientific name; the Hawaiian and English names if such be possessed by the species; the islands of the group on which the species has been recorded; the vertical range of the species; its general ecologic status, xero-, meso- or hygrophytic; and its usual stature.

It must be noted that many of the Hawaiian species are exceedingly variable, and are not yet thoroughly known from the taxonomic standpoint. Furthermore, this variability also expresses itself in the stature of the plant, which in some instances ranges from a prostate vine to a tree of eighty to one hundred ft. Many of the Hawaiian trees also occur commonly as tall shrubs; in many instances the shrub habit is more prevalent than the arborescent habit. Considerable latitude must also be given in the matter of vertical range, for the islands vary greatly in elevation, as shown by the following figures: NI'I-HAU, 1,300 ft. KAU-A'I, 5,250 ft. OAHU: Ka-ala, 4,030 ft., Kona-hua-nui, 3,105 ft. MOLOKAI: Kama-kou, 4,958 ft., Mauna Loa, 1,382 ft. MAUI: West Maui, 5,788 ft., Hale-a-ka-la, 10,032 ft. LANAI, 3,400 ft. HAWAII: Kohala, 5,489 ft., Mauna Kea, 13,825 ft.; Mauna Loa, 13,675 ft., Hu-ala-lai, 8,269 ft., Kilauea, 4,000 ft. A given species will occupy various altitudes on different islands, and in different mountain ranges, as compatible with its ecologic requirements.

The forest flora of the Hawaiian Islands has been explored by a long series of investigators and collectors, and the present list embodies the results of nearly a century and a half of botanic research. Some of the important workers have been: Nelson, 1778; Menzies, 1792–4; Chamisso, 1816; botanists of the United States Exploring Expedition, 1840; Seeman, 1848; Remy, 1853; Mann and Brigham, 1864–65; Wawra, 1869; Hillebrand, 1888; Heller, 1896; and Forbes and Rock in recent years.

In the present list the nomenclature of Engler and Prantl is generally followed, and all available data have been incorporated. This is the first time that a comprehensive and concise check list of this character has been prepared, covering the Hawaiian forest trees.

CYATHEACAE

*1. CIBOTIUM MENZIESII Hook. *Hapu i'i'i* or *Hei'i;* Greater Tree-Fern; all islands; 2,000–6,500 ft.; hydrophytic; 25–40 ft.; trunks fibrous and spongy, used for corduroy roads, etc.

*2. CIBOTIUM CHAMISSOI Kaulf. *Hapu;* Lesser Tree-Fern; all islands; 1,500–6,500 ft.; hydro- and mesophytic; 12–25 ft.; trunk as in the preceding.

*3. CIBOTIUM GLAUCUM Hook. & Arn. Glaucous Tree-Fern; *Hapu;* all islands, rare; elevation and ecology as for *C. Chamissoi;* 10–20 ft.

PANDANACEAE

†4. PANDANUS ODORATISSIMUS L. *Hala* or *Lau-Hala;* Pandanus, Screw-Pine; all islands; sea-level to 2,000 ft.; mesophytic; 15–25 ft.; leaves and fruit used by natives; widely distributed throughout the Old World tropics, the islands of the Pacific, and most abundant in Malaysia.

PALMAE

*5. PRITCHARDIA. *Loulu;* Hawaiian Fan Palm; all islands, including Nihoa and Laysan; sea-level to 4,500 ft.; hygrophytic, rarely semi-xerophytic; 8–40 ft.; there are at least two well defined species, *P. Gaudichaudii* H. Wendl., and *P. Martii* H. Wendl.; there are a number of other forms, some of which will probably merit specific status when the genus has been fully investigated.

†6. COCOS NUCIFERA L. Coconut Palm; *Niu;* all islands; littoral and lower valleys; 40–100 ft.; mesophytic; this is the northern limit of the coconut palm in the Pacific; it occurs in many tropical regions and islands, particularly in tropical America and the Pacific.

LILIACEAE

*7. DRACAENA AUREA Mann. *Hala-pepe;* all islands; 1,000–2,000 ft.; xerophytic: 20–40 ft.; wood very soft and white.

ULMACEAE

8. TREMA AMBOINENSIS (Willd.) Blume. Oahu and Molokai only; 1,000–3,000 ft.; mesophytic; 20–30 ft.; very rare; abundant on many of the islands of the Pacific, particularly in the South Pacific.

MORACEAE

9. PSEUDOMORUS BRUNONIANA (Endl.) Bureau. *Ai-ai;* Hawaiian False Mulberry; all islands; 1,000–3,000 ft.; xerophytic; 20–40 ft.; wood hard and durable, like

oak; occurs also in the Australasian region and was first found on Norfolk Island.

†10. Artocarpus incisa (Thunb.) Forst. *Ulu;* Bread-Fruit; all islands, lowlands and valleys, never wild; mesophytic; 30–60 ft.; meso- to hygrophytic; seedless; widely cultivated in the tropical regions of the Old World, particularly in tropical Asia and Polynesia.

URTICACEAE

•11. Urera sandvicensis Wedd. *O-puhe;* all islands; 800–5,000 ft.; meso- to hygrophytic; 10–25 ft., often shrubby; a valuable fiber plant in former times.

12. Pipturus albidus (Hook. & Arn.) Gray. *Ma-make;* all islands; 1,000–4,000 ft.; meso- to hygrophytic; 8–30 ft., usually small and shrubby; another valuable fiber plant in native days; reported also from Tahiti.

SANTALACEAE

•13. Santalum Freycinetianum Gaud. *Ili-ahi;* Hawaiian Sandalwood; all islands; sea-level to 6,000 ft.; xero- to mesophytic, usually the former; highly variable, 6–50 ft.; this and the following species furnished the Hawaiian sandalwood of commerce.

•14. Santalum ellipticum Gaud. *Ili-ahi;* Kauai and Oahu only; 600–1,800 ft.; mesophytic; 18–30 ft.

•15. Santalum pyrularium Gray. *Ili-ahi;* Kauai only; 3,000–4,000 ft.; meso- and hygrophytic; 35–40 ft.

•16. Santalum haleakalae Hillebd. *Ili-ahi;* Mount Hale-a-ka-la, Maui, only; 7,000–10,000 ft.; xerophytic; 15–25 ft.

AMARANTACEAE

•17. Charpentiera obovata Gaud. *Pa-pala;* all islands; 1,000–4,000 ft.; meso- and hygrophytic; 15–35 ft.

•18. Nototrichium sandwicense (Gray) Hillebd.; *Ku-lui;* all islands; 1,000–3,000 ft.; xerophytic; 8–20 ft.

NYCTAGINACEAE

•19. Pisonia umbellifera (Forst.) Seem. *Pa-pala ke-pau;* all islands; 200–2,000 ft.; hygrophytic; 15–30 ft.; wood soft and spongy.

•20. Pisonia sandwicensis Hillebd. *Pa-pala ke-pau* or *Aulu;* all islands; 1,500–3,000 ft.; xerophytic; 40–60 ft.

21. Pisonia inermis Forst. *Pa-pala ke-pau;* Molokai to Hawaii; 2,000–4,500 ft.; xerophytic; 15–18 ft.; occurs in India, Malaysia, and the islands of the South Pacific.

LAURACEAE

•22. Cryptocarya Mannii Hillebd. *Holio;* Kauai and Waianae Range of Oahu only; 2,500–4,000 ft.; meso- to xerophytic, intolerant; 18–30 ft.

SAXIFRAGACEAE

•23. Broussaisia arguta Gaud. *Kana-awa* and *Pua-ka-hui;* all islands; 1,000–3,500 ft.; hygrophytic; 6–15 ft., often shrubby.

•24. Broussaisia pellucida Gaud. *Pua-ka-nui;* all islands; 2,500–6,000 ft.; hygrophytic, 6–15 ft., often shrubby.

PITTOSPORACEAE

*25. Pittosporum glabrum Hook. & Arn. *Ho-awa;* Oahu only; 1,800–2,500 ft.; meso- and hygrophytic; 15–20 ft.

*26. Pittosporum acuminatum Mann. *Ho-awa* or *Papa-he-kili;* Kauai only; 2,000–4,000 ft.; mesophytic to semi-hygrophytic; 15–20 ft.

*27. Pittosporum spathulatum (Gray) Mann. *Ho-awa;* Oahu only; 2,000–4,000 ft.; hygrophytic; 15–20

*28. Pittosporum glomeratum Hillebd. *Ho-awa;* Oahu only; 1,500–2,500 ft.; hygrophytic; 10–15 ft.

*29. Pittosporum terminalioides Planch. *Ho-awa;* Maui, Lanai, Hawaii; 1,000–7,000 ft.; xerophytic; 15–20 ft.

*30. Pittosporum cauliflorum Mann. *Ho-awa;* Kauai and Waianae Range of Oahu only; 1,000–4,000 ft.; hygrophytic; 20–30 ft.

*31. Pittosporum Hosmeri Rock. *A-awa hua kukui;* Hawaii only; 2,000–5,000 ft.; xero- and mesophytic; 15–25 ft.

*32. Pittosporum Gayanum Rock. *Ho-awa;* Kauai only; 4,800–5,000 ft.; hygrophytic; 15–18 ft.

*33. Pittosporum insigne Hillebd. *Ho-awa;* Maui only; 2,000–6,000 ft.; hygro; phytic; 18–25 ft.

*34. Pittosporum hawaiiense Hillebd. *Ho-awa;* Hawaii only; 2,200–4,000 ft.; hygrophytic; 15–18 ft.

*35. Pittosporum kauaiense Hillebd. *Ho-awa;* Kauai only; 2,000–4,000 ft.; hygrophytic; 30–40 ft., the largest member of the genus.

*36. Pittosporum confertiflorum Gray. *Ho-awa;* Maui, Lanai, Hawaii; 2,000–5,000 ft.; hygrophytic; 15–22 ft.

LEGUMINOSAE

*37. Acacia koa Gray. *Koa;* all islands, a dominant species, formerly exceedingly plentiful; sea-level to 6,000 ft.; mesophytic to semi-xerophytic, also growing in lower rain-forests; 20–80 ft.; wood valuable, the "Hawaiian Mahogany" of commerce; used for furniture, interior trim, etc.

*38. Acacia koaia Hillebd. *Koa-ia* or *Koa-oha;* Molokai, Maui, Hawaii; 1,000–3,000 ft.; xerophytic; 20–25 ft.; wood much harder than *koa;* tree not abundant.

*39. Mezoneurum kauaiense (Mann) Hillebd. *Uhi-uhi* or *Kea;* all islands except Molokai and Lanai; 500–3,000 ft.; xerophytic; 20–30 ft.; wood extremely hard, almost black.

*40. Sophora chrysophylla (Salisb.) Seem. *Ma-mani;* all islands except Oahu and Molokai; sea-level to 10,000 ft., most abundant in upper forest zone of Hawaii; xerophytic; 4–40 ft., the largest trees occurring at the higher levels; wood very hard and durable, much used for posts.

41. Erythrina monosperma Gaud. *Wili-wili;* all islands; lowlands up to 1,500 ft.; strongly xerophytic; 20–30 ft.; deciduous; wood very white and buoyant, soft and like cork; occurs in various island groups of the South Pacific Ocean.

RUTACEAE

*42. Xanthoxylum oahuense Hillebd. *Ae* or *He-a'e;* Oahu only; 1,800–3,000 ft.; hygrophytic; 15–20 ft.

*43. Xanthoxylum hawaiiense Hillebd. *A'e* or *He-a'e;* Hawaii and Mount Hale-a-ka-la, Maui; var. *citriodora* Rock occurs on Lanai and Kauai; 1,200–6,000 ft.; xerophytic; 15–25 ft.

*44. Xanthoxylum glandulosum Hillebd. *A'e* or *He-a'e;* Maui and Hawaii; 1,000–3,000 ft.; hygrophytic; 10–15 ft.; rare.

*45. Xanthoxylum kauaiense Gray. *A'e* or *He-a'e;* Kauai, Maui, Hawaii; 1,500–4,000 ft.; meso- and xerophytic; 20–40 ft.

*46. Xanthoxylum mauiense Mann. *A'e* or *He-a'e;* all islands; 1,000–4,000 ft.; xerophytic or semi-mesophytic; 10–18 ft.; highly variable.

*47. Xanthoxylum dipetalum Mann. *A'e* or *He-a'e;* Kauai, Oahu, Hawaii; 1,000–4,000 ft.; mesophytic; 20–40 ft.

*48. Pelea clusiaefolia Gray. *Alani;* all islands; 1,000–4,000 ft.; hygrophytic; 20–30 ft.

*49. Pelea sapotaefolia Mann. *Alani;* Kauai only; 3,000–5,200 ft.; hygrophytic; 15–20 ft.

*50. Pelea waialealae Wawra. *Ano-nia* or *Alani-wai;* Kauai only; 3,000–5,200 ft.; hygrophytic; 3–20 ft.; often shrubby.

*51. Pelea auriculaefolia Gray. *Alani;* Hawaii only; 4,000–5,000 ft.; hygrophytic; 8–15 ft.; often shrubby.

*52. Pelea microcarpa Heller. *Ku-kai-moa;* Kauai only; 3,500–4,000 ft.; hygrophytic; 10–15 ft.

*53. Pelea volcanica Gray. *Alani;* Maui, Lanai, Hawaii; 2,500–6,000 ft.; hygrophytic; 25–40 ft.; quite variable.

*54. Pelea sandwicensis (Gaud.) Gray. *Alani;* Oahu only; several doubtful varieties from Kauai, Molokai, and Maui; 1,600–2,500 ft.; hygrophytic; 20–30 ft.

*55. Pelea orbicularis Hillebd. *Alani;* Kauai and West Maui only; 4,000–5,700 ft.; strongly hygrophytic; 8–10 ft.

*56. Pelea kauaiensis Mann. *Pilo-ula;* Kauai only; 4,000–5,000 ft.; strongly hygrophytic; 10–16 ft.

*57. Pelea rotundifolia Gray. *Alani;* Oahu, Ko'o-lau Range only; 1,800–2,500 ft.; hygrophytic; 10–18 ft.; often shrubby.

*58. Pelea molokaiensis Hillebd. *Alani;* Oahu, Molokai, and West Maui, most abundant on Molokai; 1,000–4,000 ft.; hygrophytic; 15–20 ft.

*59. Pelea macropus Hillebd. *Alani;* Kauai only; a variety occurs in the Kohala Mountains of Hawaii; 3,000–4,000 ft.; hygrophytic; 12–18 ft.

*60. Pelea anisata Mann. *Moki-hana;* Kauai only; 3,000–4,000 ft.; hygrophytic; 18–24 ft.; all parts very fragrant.

*61. Pelea Wawraeana Rock. *Alani;* Oahu only; 2,000–3,000 ft.; hygrophytic; 10–15 ft.

*62. Pelea multiflora Rock. *Alani;* Maui, leeward slopes of Hale-a-ka-la, only; 2,600–3,000 ft.; xerophytic; 30–40 ft.

*63. Pelea Knudsenii Hillebd. *Alani;* Kauai only; 1,500 ft.; xerophytic; 25–30 ft.

*64. Pelea barbigera (Gray) Hillebd.; *Alani;* Kauai only; 3,600–4,000 ft.; hygro- or mesophytic; 10–15 ft.; often shrubby.

*65. Pelea elliptica (Gray) Hillebd. *Alani;* Oahu, Molokai, and Maui; 1,000–3,500 ft.; 10–15 ft.; often shrubby.

*66. Pelea cinerea (Gray) Hillebd. *Alani* or *Ma-nena;* Oahu, Maui, Lanai, and Hawaii; 1,500–4,000 ft.; xerophytic; 10–35 ft.

*67. Platydesma campanulatum Mann. *Pilo kea;* all islands except Molokai and Lanai; 1,500–4,000 ft.; hygrophytic; 6–20 ft.; very variable, and often shrubby.

EUPHORBIACEAE

*68. Neowawraea phyllanthoides Rock.; Hawaii only; 2,000 ft.; xerophytic; 30–35 ft.; excessively rare; wood black, heavy.

*69. Antidesma platyphyllum Mann. *Hame* or *Ha'a;* all islands; 1,500–3,000 ft.; hygro- and mesophytic; 20–30 ft.

*70. Antidesma pulvinatum Hillebd.; *Me-hame* or *Ha'a;* all islands; 1,000–3,000 ft.; strongly xerophytic; 15–20 ft.

*71. Claoxylon sandwicense Mull.-Arg.; *Po-ola;* all islands; 1,000–2,500 ft.; xerophytic; 15–20 ft.

†72. Aleurites moluccana (L.) Willd. *Kukui;* abundant on all the islands; a dominant species in the lower forest zone, sea-level to 2,200 ft.; meso- and hygrophytic; 30–80 ft.; this is the Candle-nut or Wood-Oil tree of the South Pacific; abundant in Malaysia and the islands of the South Pacific Ocean.

*73. Euphorbia lorifolia (Gray) Hillebd.; *Koko* or *A-koko;* Molokai to Hawaii; 1,000–3,000 ft.; strongly xerophytic; 10–25 ft.; one variety is very laticiferous.

*74. Euphorbia Rockii Forbes. Oahu only; 2,000–2,500 ft.; hygrophytic; 15–20 ft., often shrubby.

ANACARDIACEAE

75. Rhus semialata sandwicensis (Gray) Engler. *Nene-leau* or *Ne-leau;* Hawaiian Sumach; all islands; 600–2,000 ft.; mesophytic; 15–25 ft.; stoloniferous, forming clumps; the range of the typical form of *R. semialata* Murr. extends from the Himalayas to China and Japan.

AQUIFOLIACEAE

*76. Ilex sandwicensis (Endl.) Loes. *Ka-wau* or *Ai-ea;* all islands; 2,000–5,000 ft.; hygrophytic; 15–40 ft.

CELASTRACEAE

*77. Perrottetia sandwicensis Gray. *Olo-mea* or *Wai-mea;* all islands; 1,000–6,000 ft.; hygro- to xerophytic; 10–20 ft., often shrubby.

SAPINDACEAE

78. Sapindus Saponaria L. *A'e* or *Ma-nele;* Maui and Hawaii; 3,000–4,500 ft.; mesophytic; 50–80 ft.; deciduous; indigenous to tropical America, but occurring on various island groups of the Pacific.

*79. Sapindus oahuensis Hillebd.; *Aulu, Ka-ulu,* or *Lono-mea;* Kauai and Oahu only; 700–1,500 ft.; mesophytic, 20–30 ft.

*80. Alectryon macrococcus Radlk.; *Ma-hoe;* all islands, but very rare; 1,000–3,000 ft.; xerophytic; 20–25 ft.

81. Dodonaea viscosa L. *A'ali'i* or *A'a-li'i ku-ma-kua;* all islands; 800–9,000 ft.; hygro- to xerophytic; 15–25 ft.; a cosmopolitan species, occurring in tropical and subtropical regions throughout the world.

*82. Dodonaea eriocarpa Smith. *A'a-li'i ku-ma-kua;* Kauai, Maui, Hawaii, 2,000–8,000 ft.; xerophytic; 8–20 ft.; often shrubby.

RHAMNACEAE

*83. Colubrina oppositifolia Brongn. *Kau-ila;* Hawaii only; 2,000 ft.; meso- to xerophytic; 25–40 ft.; wood very hard; red.

84. Alphitonia excelsa (Fenzl) Reiss. *Kau-ila* or *O'a;* all islands; 2,000–3,000 ft.; xerophytic, sometimes mesophytic; 40–80 ft.; wood very hard and heavy, red

with black streaks; a highly variable species, occurring in Malaysia, Australasia, and other islands of the Pacific.

ELAEOCARPACEAE

*85. Elaeocarpus bifidus Hook. & Arn. *Kalia;* Kauai and Oahu only; 2,000–4,000 ft.; strongly hygrophytic; 20–40 ft.

MALVACEAE

†86. Hibiscus tiliaceus L. *Hau;* all islands; abundant littoral and lowland tree; mesophytic; 20–30 ft.; forming extensive horizontal jungles by decumbent rooting branches; a cosmopolitan species, occurring in warm countries throughout the world.

*87. Hibiscus Arnottianus Gray; *Kokia keo-keo;* all islands; 1,000–2,500 ft.; hygrophytic; 15–30 ft.; beautiful white flowers.

*88. Hibiscus waimeae Heller. *Kokia keo-keo;* Kauai White Hibiscus; Kauai only; 2,000–3,000 ft.; hygrophytic; 20–30 ft.; showy white flowers.

*89. Hibiscus kokio Hillebd. *Kokia ula* or *Pu-alo-alo;* Native Red Hibiscus; all islands; rare; 300–2,000 ft.; hygrophytic; 8–40 ft., often shrubby; flowers rich red.

*90. Hibiscadelphus Giffardianus Rock, H. Wilderianus Rock, and H. hualalaiensis Rock. *Hau kuahiwi;* Hale-a-ka-la and Hawaii, excessively rare, only one or a few trees of each species, practically extinct, and of no economic value; 3,000–4,200 ft.; xerophytic; 15–20 ft.

†91. Thespesia populnea (L.) Corr. *Milo;* common littoral tree on all the islands; mesophytic; 30–40 ft.; a fine cabinet-wood; a cosmopolitan littoral species, occurring in tropical Africa, Asia, and Oceanica.

*92. Kokia Rockii Lewton. *Kokio;* Native Red Cotton Tree; Hawaii only, exceedingly rare; 2,000 ft.; xerophytic; 12–15 ft. *K. drynarioides* (Seem.) Lewton has now become extinct in the wild state; for many years it had been excessively rare.

THEACEAE

*93. Eurya sandwicensis Gray. *A-nini* or *Wa-nini;* all islands; 1,500–6,000 ft.; hygrophytic; 15–20 ft., often shrubby.

GUTTIFERAE

†94. Calophyllum inophyllum L. *Ka-mani;* a common littoral tree on all the islands, also in the lowlands; mesophytic; 50–60 ft., valued for its wood and oil; abundant in tropical Asia, Malaysia, and islands of the South Pacific.

FLACOURTIACEAE

*95. Xylosma hawaiiense Seem. *Ma-ua;* Kauai and Oahu only; 1,500–3,000 ft. meso- or semi-xerophytic; sometimes hygrophytic; 15–30 ft.

*96. Xylosma Hillebrandii Wawra; *Ma-ua;* all islands except Kauai and Oahu; 1,000–4,500 ft.; xerophytic; 10–15 ft.

THYMELAEACEAE

*97. Wikstroemia oahuensis (Gray) Rock. *Akia;* Oahu only; 600–3,000 ft.; hygrophytic; 2–15 ft., small shrub at lower levels, arborescent at the higher levels.

*98. Wikstroemia sandwicensis Meisn. *Akia;* Hawaii only; 3,000–5,000 ft.; meso- to xerophytic; 6–15 ft. often shrubby.

*99. Wikstroemia furcata (Hillebd.) Rock. *Akia;* Kauai only; 3,500–4,500 ft.; strongly hygrophytic; 12–15 ft. often shrubby.

MYRTACEAE

†100. Eugenia malaccensis L. *Ohia ai;* Mountain Apple Tree; all islands, abundant in valley floors, up to 2,000 ft.; strongly hygrophytic; 30–60 ft.; fruit juicy and edible; a cosmopolitan species, occurring in many of the island groups of the South Pacific and in tropical Asia.

*101. Eugenia sandwicense Gray. *Ohia ha* or *Pa-ihi;* all islands; 1,500–4,000 ft.; hygrophytic; 40–60 ft.

*102. Metrosideros polymorpha Gaud. *Le-hua* or *Ohia le-hua;* sea-level to 9,000 ft., in all habitats and situations; from excessively xerophytic to excessively hygrophytic; stature highly variable, from a prostrate vine to a tree of 100 ft., usually a tree of 20–50 ft.; the most abundant tree on the islands, and exceeding the *koa* in timber value; wood lumbered and used for many purposes; abundant in New Zealand and Polynesia.

*103. Metrosideros tremuloides (Heller) Rck. *Le-hua a-hi-hi;* Kauai and Oahu; 1,000–5,200 ft.; strongly hygrophytic; 10–25 ft., often shrubby.

*104. Metrosideros rugosa Gray. *Le-hua papa;* Oahu only; 2,000–4,000 ft.; hygrophytic, on exposed summit ridges; 10–15 ft., often shrubby.

*105. Metrosideros macropus Hook. & Arn. *Ohia lehua;* Kauai, Oahu, and Molokai; 1,500–3,000 ft.; hygrophytic; 30–40 ft.

ARALIACEAE

*106. Tetraplasandra hawaiiensis Gray. *Ohe;* all islands; 2,000–4,000 ft.; meso- and hygrophytic; 40–80 ft.

*107. Tetraplasandra waimeae Wawra. *Ohe ki-ko-ola;* Kauai only; 3,200–4,000 ft.; meso- and hygrophytic; 30–40 ft.

*108. Tetraplasandra waialealae Rock. Kauai only, in summit bogs; 5,000 ft.; strongly hygrophytic; 15–25 ft.

*109. Tetraplasandra lanaiensis Rock. Lanai only; 2,000 ft.; mesophytic; 20 ft.

*110. Tetraplasandra Lydgatei (Hillebd.) Harms. Oahu only; 1,500–2,000 ft.; hygrophytic; 10–20 ft.

*111. Tetraplasandra oahuensis (Gray) Harms. Oahu only; *Ohe mauka;* 1,000–3,000 ft.; hygrophytic; 15–20 ft.

*112. Tetraplasandra kaalae (Hillebd.) Harms. *Ohe;* Oahu only, Waianae Range; 3,000–4,000 ft.; strongly hygrophytic; 12–16 ft.

*113. Tetraplasandra meiandra (Hillebd.) Harms. *Ohe;* all islands; 1,000–4,000 ft.; xero- to hygrophytic; 20–50 ft., attaining greatest stature in arid regions.

*114. Reynoldsia sandwicensis Gray; *Ohe* or *Ohe makai;* all islands; lowlands to 1,500 ft.; xerophytic; 15–60 ft.; deciduous.

*115. Pterotropia gymnocarpa Hillebd. *Ohe-ohe;* Oahu only; 1,500–2,500 ft.; strongly hygrophytic; 15–30 ft.

*116. Pterotropia kavaiensis (Mann) Hillebd. *Ohe-ohe;* Kauai only; 2,500–4,000 ft.; meso- to hygrophytic; 40–60 ft.

*117. Pterotropia dipyrena (Mann) Hillebd. *Ohe-ohe;* Maui, Lanai and Hawaii; 2,000–4,500 ft.; xero- to hygrophytic; 20–60 ft.

*118. Cheirodendron Gaudichaudii (DC.) Seem. *Olapa;* all islands; 2,000–4,000 ft.; hygrophytic; 30–50 ft.

*119. Cheirodendron platyphyllum (Hook. & Arn.) Seem. *Lapa-lapa;* Kauai and Oahu only; 3,000–5,000 ft.; strongly hygrophytic.

EPACRIDACEAE

120. **Styphelia tameiameia** (Cham.) F. Muell. *Pu-keawe* or *Pua-keawe;* all islands; 1,000–10,000 ft.; all habitats, from xero- to hygrophytic; shrubby at the lower, arborescent (10–18 ft.) at the higher levels; known also from Tahiti and Eimeo of the Society Group.

MYRSINACEAE

•121. **Suttonia kauaiensis** (Hillebd.) Mez. *Ko-lea;* Kauai only; 2,000 ft.; 25–35 ft.; hygrophytic.

•122. **Suttonia Wawraea** Mez. *Ko-lea;* Kauai only; 3,000–4,500 ft.; strongly hygrophytic; 10–15 ft., often shrubby.

•123. **Suttonia lanaiensis** (Hillebd.) Mez. Lanai and Maui only; 1,000–2,500 ft.; meso- to xerophytic; 20–30 ft.

•124. **Suttonia Fernseei** Mez. Kauai only; 3,000 ft.; hygrophytic; size unknown; very rare.

•125. **Suttonia spathulata** Rock. *Ko-lea;* Maui only; 6,500 ft.; xerophytic; 15–20 ft.

•126. **Suttonia volcanica** Rock. *Ko-lea;* Maui and Hawaii only; 2,000–5,500 ft.; strongly xerophytic; 12–20 ft.

•126. **Suttonia Knudsenii** Rock. *Kolea;* Kauai only; 3,000–4,000 ft.; strongly hygrophytic; 15 ft., often shrubby.

•127. **Suttonia Hillebrandii** Mez. *Ko-lea;* Kauai and Oahu only; 2,500–4,000 ft.; hygrophytic; 15–20 ft.

•128. **Suttonia Lessertiana** (A.DC.) Mez. *Ko-lea;* all islands; 1,500–5,500 ft.; hygrophytic; 20–60 ft.; very variable.

•129. **Suttonia sandwicensis** (A.DC.) Mez; *Ko-lea lau-lii;* all islands; 3,000–6,000 ft.; hygrophytic; 15–25 ft., often shrubby.

•130. **Suttonia lanceolata** (Wawra) Rock. Kauai only; 4,000–5,200 ft.; strongly hygrophytic, summit bogs only; 8–15 ft., often shrubby.

SAPOTACEAE

•131. **Chrysophyllum polynesicum** (Benth. & Hook.) Hillebd. *Ke-ahi;* all islands except Hawaii; 1,000–3,000 ft.; strongly xerophytic; 20–35 ft.

•132. **Sideroxylon sandwicense** (Gray) Benth. & Hook. *Ala'a or Ka-ulu;* all islands except Hawaii; 1,000–4,000 ft.; xero- to hygrophytic, chiefly the former; 30–50 ft.

•133. **Sideroxylon Ceresolii** Rock. Maui only; 3,000 ft.; hygrophytic; 20–30 ft.; rare.

•134. **Sideroxylon rhynchospermum** Rock. *Ala'a;* Maui only; 1,300 ft.; hygrophytic; 30–35 ft.; scarce.

•135. **Sideroxylon auahiense** Rock. *Ala'a;* Maui and Hawaii only; 3,000 ft.; xerophytic; 25–40 ft.

•136. **Sideroxylon spathulatum** Hillebd. *Ala'a;* Oahu, Molokai, Lanai; 1,000–3,000 ft.; mesophytic; 12–18 ft., often shrubby.

EBENACEAE

•137. **Maba sandwicensis** A.DC. *Lama;* Hawaiian Ebony; all islands; 1,000–3,000 ft.; xero- to hygrophytic, chiefly the former; 30–40 ft.; wood very hard, rich brown color.

•138. **Maba Hillebrandii** Seem. *Lama;* Oahu only; 1,500–2,500 ft.; hygrophytic; 20–30 ft.

OLEACEAE

*139. **Osmanthus sandwicensis** (Gray) Knobl. *Pua* or *Olo-pua;* Hawaiian Olive; all islands; 600–4,000 ft.; xero- to mesophytic, chiefly the former; 30–60 ft.; wood very hard.

LOGANIACEAE

*140. **Labordia molokaiana** Baillon. *Ka-maka-hala;* Molokai; 3,000 ft.; strongly hygrophytic; 30 ft.

*141. **Labordia membranacea** Mann. *Ka-maka-hala;* Oahu only; 1,500–2,500 ft.; hygrophytic; 10–20 ft.

*142. **Labordia sessilis** Gray. *Ka-maka-hala;* Oahu only; 1,000–3,000 ft.; strongly hygrophytic; 10–35 ft., often shrubby.

*143. **Labordia tinifolia** Gray. *Ka-maka-hala;* Kauai to Maui; 1,000–3,000 ft.; meso- to xerophytic; 15–20 ft., often shrubby.

APOCYNACEAE

*144. **Pteralyxia macrocarpa** (Hillebd.) Schum. *Ka-ulu;* Oahu only; hygrophytic; 1,000–3,000 ft.; rare; 15–25 ft.

*145. **Rauwolfia sandwicensis** A.DC. *Hao;* all islands; 1,500–2,500 ft.; meso- to hygrophytic, sometimes xerophytic; 15–20 ft., often shrubby.

*146. **Ochrosia sandwicensis** Gray. *Ho-lei;* all islands; 1,000–4,000 ft.; xero- to mesophytic; 10–25 ft., often shrubby.

BORRAGINACEAE

†147. **Cordia subcordata** Lam. *Kou;* all islands, formerly an abundant littoral tree. now very rare; mesophytic; 15–50 ft.; wood with beautiful grain, formerly prized by the natives; occurs in the Indian and South Pacific Oceans and throughout Polynesia.

SOLANACEAE

*148. **Nothocestrum longifolium** Gray. *Ai-ea;* all islands; 1,000–5,000 ft.; hygrophytic; 10–20 ft , often shrubby.

*149. **Nothocestrum breviflorum** Gray. *Ai-ea;* Hawaii only; 2,000–2,800 ft.; xerophytic; 30–35 ft.; wood very soft.

*150. **Nothocestrum latifolium** Gray. *Ai-ea;* all islands except Hawaii; 1,500–3,000 ft.; xerophytic; 20–30 ft.

*151. **Nothocestrum subcordatum** Mann. *Ai-ea;* Kauai and Oahu only; 1,500–3,500 ft.; meso- to hygrophytic; 25–35 ft.

*152. **Solanum Carterianum** Rck. *Pua-nana-ho-nua;* Oahu only; 1,500 ft.; hygrophytic; 15–20 ft.; exceedingly rare (one tree).

MYOPORACEAE

*153. **Myoporum sandwicense** (ADC.) Gray. *Naio;* Bastard Sandalwood; all islands; a very plentiful forest tree, from sea-level to 10,000 ft.; xero- to hygrophytic, chiefly the former; stature very variable, from a shrub of 2–3 ft. up to a tree of 50–65 ft.; wood fragrant, like *Santalum*.

RUBIACEAE

*154. **Gouldia axillaris** Wawra. *Ma-nono;* all islands; 2,500–3,500 ft.; hygrophytic; 20–25 ft.; variable.

*155. **Gouldia elongata** Heller. *Ma-nono;* Kauai; 2,000 ft.; hygrophytic; 10–20 ft., often shrubby.

*156. Gouldia macrocarpa Hillebd. *Ma-nono;* Kauai and Oahu only; 2,000–4,000 ft.; hygrophytic, 10–20 ft.

*157. Gardenia Brighami Mann. *Na'u;* all islands; 1,000–3,000 ft.; xerophytic; 10–18 ft., often shrubby; flowers fragrant.

*158. Gardenia Remyi Mann. *Na'u;* all islands; 1,000–4,000 ft.; hygrophytic; 20–40 ft.; flowers white, fragrant.

159. Plectronia odorata (Forst.) F. Müll. *Ala-hee* or *Wala-hee;* all islands; 600–2,200 ft., abundant; xero- to mesophytic; 6–20 ft., often shrubby.

*160. Bobea elatior Gaud. *Aha-kea;* Kauai, Oahu, Molokai, Hawaii; 1,000–4,000 ft.; hygrophytic; 25–40 ft.; wood yellow.

*161. Bobea Hookeri Hillebd.; *Aha-kea;* Oahu, Molokai, Maui, very rare; 1,000–3,000 ft ; 25–35 ft.; hygrophytic.

*162. Bobea sandwicensis (Gray) Hillebd. *Aha-kea;* West Maui, Molokai, Lanai; 1,000–2,000 ft.; 15–25 ft., often shrubby.

*163. Bobea timonioides (Hook. f.) Hillebd. *Aha-kea;* Hawaii only; xerophytic; 800–2,000 ft.; size unknown; very rare.

*164. Bobea Mannii Hillebd.; *Aha-kea;* Kauai only; 2,000–3,000 ft.; hygro- to mesophytic; 20–30 ft.

*165. Straussia kaduana (Cham. & Schlecht.) Gray. *Ko-piko kea;* Oahu, Molokai, Lanai; common, variable; 1,000–3,000 ft.; hygrophytic; 10–20 ft., often shrubby.

*166. Straussia longissima Rock. *Ko-piko;* Oahu only; 1,000 ft.; hygrophytic; 12–20 ft.; rare.

*167. Straussia onocarpa Hillebd.; *Ko-piko;* Kauai, Maui, Lanai; 1,000–3,000 ft.; hygrophytic; 25–50 ft.; varieties occur on Molokai and Hawaii.

*168. Straussia Fauriei Lévl. *Ko-piko;* Oahu and Lanai; 2,000–3,000 ft.; hygrophytic; 10–15 ft.

*169. Straussia leptocarpa Hillebd.; *Ko-piko;* Maui only; 2,000–3,000 ft.; xero- to mesophytic; 15–20 ft.

*170. Straussia Mariniana (Cham. & Schlecht.) Gray; *Ko-piko;* Kauai, Oahu Maui; 2,500–3,500 ft.; hygrophytic; 10–20 ft.

*171. Straussia hawaiiensis Gray. Hawaii only; *Ko-piko;* 2,000–4,000 ft.; meso- to hygrophytic; 20–35 ft.

*172. Straussia Hillebrandii Rock. *Ko-piko;* Hawaii and Molokai; 2,000–4,000 ft.; hygrophytic; 15–20 ft.

*173. Psychotria hexandra Mann. Kauai and Oahu; 1,000 3,000 ft.; hygrophytic; 15–20 ft.

*174. Psycotria grandiflora Mann. Kauai only; 2,000–3,000 ft.; hygrophytic; 15–20 ft., often shrubby.

*175. Psychotria hirta (Wawra) Heller; Kauai only; 2,000–3,000 ft.; hygrophytic; 10–20 ft., often shrubby.

*176. Coprosma montana Hillebd. *Pilo;* Kauai, Maui, and Hawaii; 4,000–10,000 ft.; xero- to hygrophytic; 3–20 ft., variable, often shrubby, sometimes prostrate.

*177. Coprosma rhyncocarpa Gray; *Pilo;* Hawaii only; 3,000–6,000 ft.; meso- to hygrophytic; 15–20 ft., often shrubby.

*178. Coprosma Vontempskyi Rock. *Pilo;* Maui only; 4,000 ft.; hygrophytic; 15–20 ft.; precinctive.

*179. Coprosma Grayana Rock. *Pilo;* Hawaii only; 3,000 ft.; hygrophytic; 20–25 ft.; precinctive.

*180. Coprosma pubens Gray. *Pilo;* all islands; 2,000–5,000 ft.; hygrophytic; 10–20 ft., often shrubby.

*181. Coprosma kauaiensis (Gray) Heller. *Koi;* Kauai only; 2,000–3,000 ft.; hygrophytic; 15–20 ft., often shrubby.

*182. Coprosma waimeae Wawra. *Olena;* Kauai only; 3,500–4,000 ft.; hygrophytic; 15–20 ft.

*183. Coprosma longifolia Gray. *Pilo;* Kaui, Oahu, Lanai, Hawaii; 1,000–4,000 ft.; hygrophytic; 15–20 ft., often shrubby.

†184. Morinda citrifolia L. *Noni;* all islands, lowlands, around native settlements; meso- to xerophytic; 15–25 ft.; occurring also in Asia and Australia.

*185. Morinda trimera Hillebd. *Noni kua-hiwa;* Oahu, Maui, very rare; 2,000–4,000 ft.; hygrophytic; 15–30 ft.

CAMPANULACEAE

*187. Clermontia grandiflora Gaud. Molokai, Maui, Lanai; 2,000–5,000 ft.; hygrophytic; 6–18 ft., often shrubby.

*188. Clermontia drepanomorpha Rock. Hawaii only; 4,000–5,000 ft.; strongly hygrophytic; 12–20 ft.

*189. Clermontia persicaefolia Gaud. Oahu only; 1,000–4,000 ft.; hygrophytic; 12–18 ft., often shrubby.

*190. Clermontia oblongifolia Gaud. Oahu, Molokai, Maui; 1,000–4,000 ft.; hygrophytic; 15–25 ft., often shrubby.

*191. Clermontia kohalae Rock. Hawaii only; 1,500–2,500 ft.; hygrophytic; 15–18 ft.

*192. Clermontia leptoclada Rock. Hawaii only; 4,000–4,500 ft.; strongly hygrophytic; 18–20 ft.

*193. Clermontia hawaiiensis (Hillebd.) Rock. Hawaii only; 3,000–5,000 ft.; hygrophytic; 15–25 ft., often shrubby.

*194. Clermontia Gaudichaudii (Gaud.) Hillebd. *Ha-ha;* Kauai only; 3,500–4,500 ft.; strongly hygrophytic; 15–25 ft., often shrubby.

*195. Clermontia Peleana Rck. Hawaii only, very rare; 3,800 ft.; hygrophytic; 20 ft.; precinctive.

*196. Clermontia arborescens (Mann) Hillebd. Molokai, Maui, Lanai; 2,000–4,500 ft.; hygrophytic; 15–25 ft.

*197. Clermontia tuberculata Forbes. Maui only; 5,000 ft.; hygrophytic; 12–15 ft.; very rare, precinctive.

*198. Clermontia coerulea Hillebd. Hawaii only; 1,800–4,500 ft.; hygrophytic; 15–20 ft.; abundant.

*199. Clermontia haleakalensis Rock. Hale-a-ka-la, Maui, only; 7,000 ft.; strongly hygrophytic; 10–20 ft.; very precinctive and rare,.

*200. Cyanea arborea (Gray) Hillebd. Maui only, practically extinct; 4,000-5,000 ft., meso- to xerophytic; 12–25 ft., only one tree known.

*201. Cyanea leptostegia Gray. *Ha-ha-lua;* Kauai only; 2,000–4,000 ft.; mesophytic to semi-hygrophytic; 20–40 ft.

GOODENIACEAE.

*202. Scaevola Chamissoniana Gaud. *Nau-paka;* all islands; 800–5,000 ft. hygrophytic; 15–20 ft., often shrubby.

*203. Scaevola glabra Hook. & Arn. *Ohe-nau-paka;* Kaui, Oahu, West Maui; 3,000–5,000 ft.; strongly hygrophytic; 10–20 ft., usually shrubby.

*204. **Scaevola procera** Hillebd. *Nau-paka;* Kauai, Molokai, Maui; 2,000–4,000 ft.; hygrophytic; 12–16 ft., usually shrubby.

COMPOSITAE

*205. **Dubautia plantaginea** Gaud.; *Nae-nae;* all islands; 1,800–6,000 ft.; hygrophytic, sometimes semi-xerophytic; 10–18 ft.

*206. **Raillardia arborea** Gray. *Nae-nae;* Hawaii, Mauna Kea only, rare; 7,000–11,000 ft.; xerophytic; 18–20 ft., often a small shrub.

*207. **Raillardia struthioloides** Gray. *Nae-nae;* Hawaii, Mauna Kea only; 7,000–11,500 ft.; xerophytic; 18–25 ft., often a small shrub.

*208. **Raillardia Menziesii** Gray. *Nae-nae;* Maui, Hale-a-ka-la only; 6,000–10,000 ft.; xerophytic; 15–22 ft., often a shrub.

*209. **Hesperomannia arborescens** Gray. Hawaiian Tree Thistle; Oahu and Lanai, evidently becoming extinct; 2,000–3,000 ft; hygrophytic; 10–20 ft.

*210. **Hesperomannia Lydgatei** Forbes; Kauai only, very rare; 3,000 ft.; hygrophytic; 10–20 ft.

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INDEX TO AMERICAN BOTANICAL LITERATURE

1915-1917

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the word America being used in the broadest sense.

Reviews, and papers that relate exclusively to forestry, agriculture, horticulture, manufactured products of vegetable origin, or laboratory methods are not included, and no attempt is made to index the literature of bacteriology. An occasional exception is made in favor of some paper appearing in an American periodical which is devoted wholly to botany. Reprints are not mentioned unless they differ from the original in some important particular. If users of the Index will call the attention of the editor to errors or omissions, their kindness will be appreciated.

This Index is reprinted monthly on cards, and furnished in this form to subscribers at the rate of one cent for each card. Selections of cards are not permitted; each subscriber must take all cards published during the term of his subscription. Correspondence relating to the card issue should be addressed to the Treasurer of the Torrey Botanical Club.

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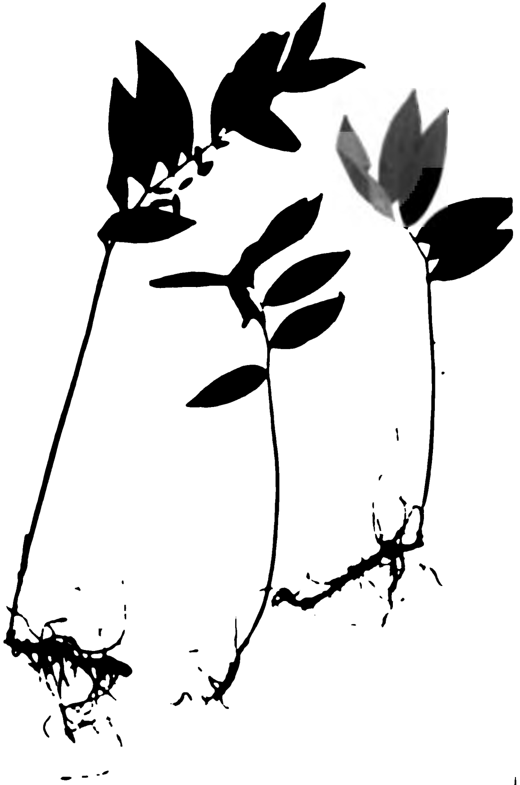
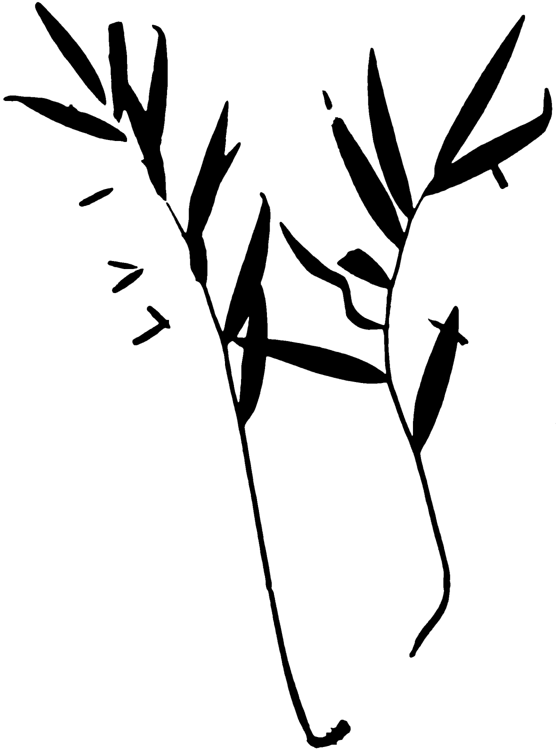
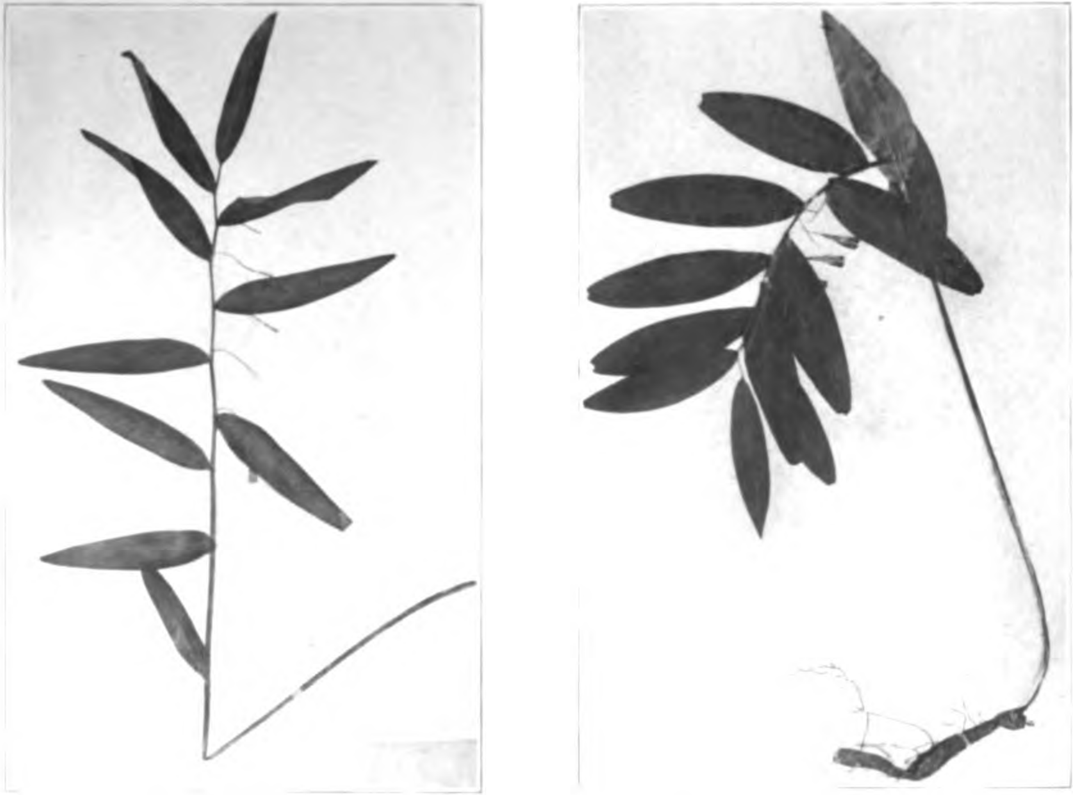


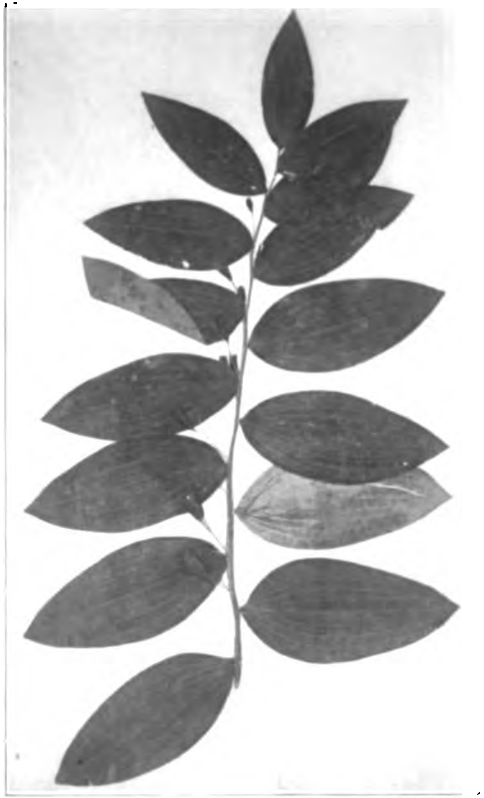
A. POLYGONATUM PUBESCENS AUSTRALE (FARWELL) GATES



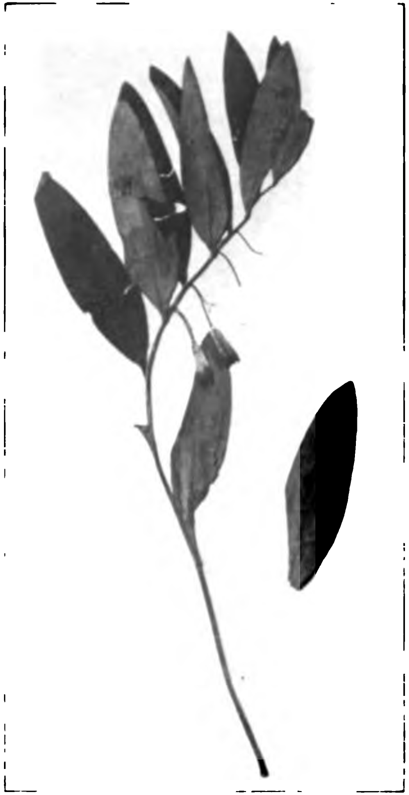
B. POLYGONATUM BIFLORUM (WALT.) ELL.



POLYGONATUM BIFLORUM HEBETIFOLIUM GATES



A. POLYGONATUM COMMUTATUM VIRGINICUM (Greene) Gates



B. POLYGONATUM COBRENSIS (Wooton & Standley) Gates

Vol. 44 No. 4.

BULLETIN

OF THE

TORREY BOTANICAL CLUB

Contributions to the Mesozoic flora of the Atlantic coastal plain, XII.—Arkansas[*]

EDWARD W. BERRY

(WITH PLATE 7)

The Upper Cretaceous of the Western Gulf area contains littoral sand beds of a magnitude great enough to be considered formational units. These are not restricted to a narrow horizon and the belief has been frequently expressed and is apparently probable that these sand formations are the time equivalents of several marine formations that are differentiated elsewhere in this area. The Woodbine sand of northeastern Texas is a case in point and another example is furnished by the Bingen sand of southwestern Arkansas. Both are without marine fossils so far as known and both contain fossil plants, those of the Woodbine sand having been reviewed by me[†] in 1912.

Recently Mr. H. D. Miser, of the United States Geological Survey, has sent me several small collections of fossil plants from the Bingen sand. These are, so far as I know, the first fossil plants collected from the Bingen sand. While the material is poor and not greatly varied, a number of species are determinable and these, while not as conclusive as might be wished, nevertheless shed considerable light on the correlation of the formation. Mr. Miser is to be congratulated for the care with which he has collected from such unpromising material.

The Bingen sand was named by Hill in 1888[‡] from the town

[The BULLETIN for March (44: 117–166. *pl.* *4–6*) was issued March 27, 1917.]

[*] The last previous contribution of this series appeared in the Bull. Torrey Club 43: 283–304. *pl.* *16*. 1916.

[†] Berry, E. W. No. VIII of this series. Bull. Torrey Club 39: 387–406. *pl.* *30–32*. 1912.

[‡] Hill, R. T. Ann. Rept. Geol. Surv. Arkansas for 1888, 2. 56–58.

of Bingen in Hempstead County, Arkansas. It comprises near shore (littoral and estuarine) deposits of gravels and white to brown sands and clays with considerable lignitic material and occasionally fairly well preserved fossil plants. It outcrops in a nearly east and west direction commencing at the Ouachita River and showing isolated patches along the edge of the Paleozoic rocks in Clark County. Except where it is cut out by river bottoms it forms an almost continuous sheet across Pike, Hempstead, Howard and Sevier Counties. Veatch,* who mapped this area in 1902 and 1903, clearly recognized that while the Bingen sand of southwestern Arkansas was the lithologic counterpart of the Woodbine sand of northeastern Texas it was the chronological equivalent of not only more or less of the Woodbine but of a considerable portion of the overlying Upper Cretaceous, including at least all of the Eagle Ford formation of the Texas region and possibly the Austin and the earlier part of the Brownstown formation. Mr. Miser in his recent work in the Caddo Gap and De Queen quadrangles proposes to distinguish a lower and an overlapping upper Bingen, both of which have furnished fossil plants, although the collections from both are not far from the contact of the two and therefore well above the base of the Bingen in the one case and well below the top in the other.

The plants include twenty-seven determinable species for the most part identical with well-known Upper Cretaceous forms, and a fern pinnule that I have not ventured to name. The determined forms comprise one fern, four conifers, two cycadophytes (?), and twenty dicotyledons. The most abundant forms are *Sequoia concinna* and a new species of *Dewalquea.* Among the dicotyledons there are three species each of *Myrica* and *Ficus*, two each of *Salix*, *Liriodendron* and *Andromeda*, and one each of *Dewalquea*, *Menispermites*, *Colutea*, *Leguminosites*, *Manihotites*, *Cinnamomum*, *Sapindus* and *Cordia*. A list of the species with their outside distribution is shown in the accompanying table.

The largest collection (seventeen species) and the best preserved material comes from the Big Railroad Cut locality which is near the base of Mr. Miser's upper Bingen. Considering the Bingen flora as a whole it may be noted that it contains only one species—the abundant *Dewalquea*—not known from other Upper Cretaceous formations of the Atlantic Coastal Plain. There are five species common to the little known flora of the Woodbine sand of northeastern Texas. Eighteen of the Bingen species occur in the Tuscaloosa formation of the Eastern Gulf area, six continue upward into the Eutaw formation and one is found as high as the Ripley. Eleven species are common to the Dakota sandstone of the Western Interior and an identical number ranges northward far enough to be present in the Atane beds of western Greenland. Fifteen of the Bingen plants are recorded from the Black Creek formation of the Carolinas and there are seventeen common forms in both the Raritan and Magothy formations of

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* Veatch, A. C. U. S. Dept. Int. Geol. Surv. Professional Paper 46: 24. 1906.

	Big Railroad Cut near Maxwell Spur, Pike County	Adams' Kaolin Cuts near Murfreesboro, Pike County	Mine Creek near Nashville, Howard County	Woodbine	Tuscaloosa	Eutaw	Ripley	Black Creek	Dakota	Raritan	Magothy	Atane	Patoot	Colorado	Montana	Cenomanian	Turonian
Fern pinnule		×															
Dicksonia groenlandica		×	×		×					×		×	×				
Sequoia concinna	×				?					?	×		×			?	?
Sequoia heterophylla	×				×			×		×	×	×	×		×	×	
Widdringtonites subtilis	×				×			×		×	×	×					
Araucaria darlingtonensis	×				×			×									
Podozamites marginatus		×			×					×	×	×					
Podozamites sp.			×														
Myrica cliffwoodensis	×							×			×						
Myrica longa			×	×	×				×		×	×	×				×
Myrica cinnamomifolia			×							×							
Salix flexuosa	×	×	×		×	×		×	×	×	×						
Salix Lesquereuxii	×	×			×			×	×	×	×						
Ficus crassipes	×	×	×		×	×		×	×		×	×					
Ficus daphnogenoides	×			×	×			×	×	×	×						
Ficus ovatifolia (?)			×			×		×		×							
Dewalquea insigniformis	×	×															
Liriodendron Meekii	×				×			×	×	×		×					
Liriodendron quercifolium			×	×						×							
Menispermites integrifolia	×				×												
Colutea primordialis	×			×					×	×	×	×					
Leguminosites omphalobioides	×				×				×		×						
Manihotites georgiana	×					×	×	×									
Sapindus Morrisoni	×		×	×				×	×		×	×	×				
Cinnamomum Newberryi (?)			×		×	×		×	×	×	×	×	×				
Andromeda novae-caesareae			×		×	×		×		×	×						
Andromeda Parlatorii			×		×			×	×	×	×	×					
Cordia apiculata	×				×					×	×						

the northern Atlantic coastal plain. This serves to fix the age of the Bingen within the somewhat broad limits extending from the base of the Raritan to the base of the Ripley. The chief interest in the present contribution is, however, the somewhat more definite indications of age furnished by these collections.

The first two localities, namely the Big Railroad Cut and Adams Kaolin cuts in Pike County, are definitely located by Mr. Miser in the lower part of the upper Bingen and I shall consider these first. A total of nineteen species are determined. Of these three occur in the Woodbine and fourteen occur in the Tuscaloosa, eleven in the Raritan, thirteen in the Magothy, eleven in the Black Creek, three in the Eutaw and one in the Ripley. Among the upper Bingen plants are eight that are unknown as early as the Raritan. This fact and the presence of the *Manihotites*, which is a characteristic Eutaw and Ripley species, indicates that the upper Bingen is to be correlated with a part, presumably the upper, of the Woodbine, with the upper part of the Tuscaloosa and with the Eutaw formation of the Eastern Gulf area.

The correlation of the upper Bingen with the Eutaw confirms the suggestion of Veatch that it represents the interval during which the Eagle Ford formation was deposited throughout the Texas area, and as he and other students have suggested it may include the chronologic equivalent of still higher formations differentiated in Texas. This can only be determined paleobotanically by the discovery of more abundant materials from a number of horizons.

The locality in Howard County has furnished but twelve species, only four of which are found in the upper Bingen. It has not furnished any trace of the *Dewalquea* which is so common and characteristic a form in the upper Bingen nor are any of the four conifers of the latter represented. Forms like *Myrica cinnamomifolia* and *Liriodendron quercifolium*, peculiar to the Raritan, indicate that the lower Bingen is to be correlated with the Raritan, the lower Tuscaloosa and a part, presumably the lower, of the Woodbine.

The boundaries of all of the Upper Cretaceous formations of the Coastal Plain, determined as they have been by lithological differences instead of by their contained faunas or floras, overlap, and the limits of the same formation are not chronologically coterminous when traced from locality to locality, so that final precision in correlation must wait for the discovery and study of abundant paleontological materials.

The species that have been determined from the Bingen sand are discussed in the following pages. This discussion is in most cases brief and only one or two important references to the literature are cited.

FILICALES

CYATHEACEAE

DICKSONIA Presl

DICKSONIA GROENLANDICA Heer

Dicksonia groenlandica Heer, Fl. Foss. Arct. 6²: 23. *pl.* 35. *f.* 8, 9. 1882.

Dicksonia borealis Heer, *Ibid. pl.* 44. *f.* 2.

Anemia stricta Newberry, Fl. Amboy Clays 38. *pl.* 3. *f.* 1, 2. 1896.

This characteristic species, which has a considerable vertical range in the Upper Cretaceous of the west coast of Greenland, is common in the middle Raritan of New Jersey and also occurs in the lower part of the Tuscaloosa formation of western Alabama. It is sparingly represented in both the lower and upper Bingen in Arkansas.

OCCURRENCE: Kaolin cuts in sec. 24 T8S. R24. W, Pike County; Mine Creek, three and one half miles north of Nashville, Howard County.

CYCADALES (?)

CYCADACEAE (?)

PODOZAMITES Fr. Braun

PODOZAMITES MARGINATUS Heer

Podozamites marginatus Heer, Fl. Foss. Arct. 6²: 43. *pl.* 16. *f.* 10. 1882.

This species was originally described from the Atane beds of western Greenland. It occurs in the Raritan formation of New Jersey and Maryland, in the Magothy formation of New Jersey, and is very common in the lower part of the Tuscaloosa formation in western Alabama.

OCCURRENCE: Adams Kaolin cuts near Murfreesboro, Pike County.

PODOZAMITES sp.

Small fragments of a species of *Podozamites* occur in the collection from the east part of Section 2, but whether they represent *Podozamites marginatus*, which occurs elsewhere in the Bingen sand, as well as in the Tuscaloosa formation of the Eastern Gulf area, or some other of the numerous Cretaceous forms referred to this genus it is impossible to determine.

OCCURRENCE: Mine Creek, three and one half miles north of Nashville, Howard County..

CONIFERALES

PINACEAE

SEQUOIA Endlicher

SEQUOIA HETEROPHYLLA Velenovsky

Sequoia heterophylla Velenovsky, Gym. Böhm. Kreidef. *22. pl. 12. f. 12; pl. 13. f. 2–4, 6–9.* 1885.

This characteristic species, described originally from the Cenomanian of Bohemia, may be readily recognized by the form of the foliage—the flat, lanceolate, decurrent leaves above, and the short and appressed leaves below. It has a wide geographical range as may be seen from the accompanying table of distribution. It has not yet been found but probably will be eventually discovered in the Woodbine sand, since it is not uncommon in the Tuscaloosa beds of western Alabama.

A considerable number of fragmentary but characteristic specimens have been collected from near the base of the upper part of the Bingen sand.

OCCURRENCE: Big Railroad Cut, one mile southwest of Maxwell Spur, Pike County.

SEQUOIA CONCINNA Heer

Sequoia concinna Heer, Fl. Foss. Arct. 7: 13. *pl. 49. f. 8b, c; pl. 50. f. 1b; pl. 51. f. 2–10; pl. 52. f. 1–3; pl. 53. f. 1b.* 1883; Berry, Geol. Surv. of New Jersey, Bull. 3: 96. 1911.

This species (FIGS. 1–5) was described by Heer from the Patoot beds of Greenland and has subsequently been recorded from the Raritan and Magothy formations of the United States and from the Emscherian of Italy. The foliage is distinguished with difficulty from that of *Sequoia fastigiata* (Sternberg) Heer, *Sequoia ambigua* Heer, and various other species. In the absence of well preserved cones it is doubtful if the species can be determined. Similar foliage from the Tuscaloosa formation of western Alabama I have referred to *Sequoia fastigiata*. The reference of the Bingen sand material to *S. concinna* rather than to the latter species is due to the presence of cones associated with the twigs in the latter formation.

OCCURRENCE: Big Railroad Cut, one mile southwest of Maxwell Spur, Pike County.

WIDDRINGTONITES Endlicher

WIDDRINGTONITES SUBTILIS Heer

Widdringtonites subtilis Heer, Fl. Foss. Arct. 3^2: 101. *pl. 28. f. 1b.* 1874. Berry, U. S. Dept. Int. Geol. Surv. Professional Paper 84: 25. *pl. 2. f. 14–17.* 1914.

This species was described from the Atane beds of Greenland by Heer in 1874. His material was, however, extremely limited. Subsequently it was found in considerable abundance in the Raritan formation of New Jersey, and still more recently Hollick recorded it from Marthas Vineyard and Block Island (Magothy formation). It may be questioned if some of the coniferous material described by Velenovsky from the Bohemian Cretaceous under other names should not be compared with the present form. It is even more slender than *Widdringtonites Reichii*, with much shorter twigs, which have the appearance of having been somewhat lax in habit. The leaves are usually more elongated, close set, and appressed, narrowly lanceolate, straight and scalelike; they are said by Heer to be somewhat spread and falcate proximad. Remains of this latter sort occur in the Tuscaloosa formation of Alabama where they bear characteristic valvate cones like those of the existing *Widdringtonia*.

This species has not yet been discovered in the Woodbine sand of Texas but its remains are very abundant in the lower part of the upper member of the Bingen sand.

OCCURRENCE: Big Railroad Cut, one mile southwest of Maxwell Spur, Pike County.

ARAUCARIA Jussieu

ARAUCARIA DARLINGTONENSIS Berry

Araucaria darlingtonensis Berry, U. S. Dept. Int. Geol. Surv. Professional Paper 84: 20. *pl. 3. f. 1.* 1914.

Seed obovate in outline with broadly rounded apex, straight lateral margins, and somewhat narrowed rounded base, 1.25 cm. in length and 0.75 cm. in width across the widest part, 0.5 cm. wide at base.

This species was based on the seed of an araucarian conifer from the Middendorf member of the Black Creek formation of South Carolina where it was associated with the foliage of *Araucaria bladenensis* Berry. A single specimen is contained in the collection from the basal part of the upper member of the Bingen sand.

OCCURRENCE: Big Railroad Cut, one mile southwest of Maxwell Spur, Pike County.

MYRICALES

MYRICACEAE

MYRICA Linné

MYRICA CLIFFWOODENSIS Berry

Myrica cliffwoodensis Berry, Bull. Torrey Club **31**: 73. *pl. 4. f. 1.* 1904.

This species was based on small spherical fruits of the ***Myrica*** type from the Magothy formation of New Jersey which were subsequently found in the Black Creek formation of North Carolina. Similar fruits are extremely common in some of the pieces of clay from the basal part of the upper member of the Bingen sand.

OCCURRENCE: Big Railroad Cut, one mile southwest of Maxwell Spur, Pike County.

MYRICA CINNAMOMIFOLIA Newberry

Myrica cinnamomifolia Newberry, Fl. Amboy Clays 64. *pl. 22. f. 9–14.* 1896.

The finding of this species in the lower member of the Bingen sand is of considerable interest since it has heretofore been known only from the middle part of the Raritan formation in the New Jersey area where it is not uncommon. Its reference to the genus *Myrica* is questionable.

OCCURRENCE: Mine Creek, three and one half miles north of Nashville, Howard County.

MYRICA LONGA (Heer) Heer

Proteoides longus Heer, Fl. Foss. Arct. 3^2: 110. *pl. 29. f. 8b; pl. 31. f. 4, 5.* 1874.

Myrica longa Heer, *Ibid.* 6^2: 65. *pl. 18. f. 9b; pl. 29. f. 15–17; pl. 33. f. 10; pl. 41. f. 4d.* 1883.

Leaves of various sizes, linear to lanceolate in outline, with a stout midrib; numerous thin, ascending, camptodrome secondaries; entire margins, obtusely pointed apex; narrowly decurrent base and long stout petioles.

This species was described by Heer as a *Proteoides* and subsequently referred to the genus *Myrica*. It occurs in both the Atane and Patoot beds of Greenland, in the Dakota sandstones of the West, in the Magothy formation of Maryland, in the Woodbine formation of Texas, and is very common in the Tuscaloosa formation of Alabama. It is sparingly represented in the lower member of the Bingen sand. Abroad it has been recorded[*] from the lower Turonian of Bohemia.

OCCURRENCE: Mine Creek, three and one half miles north of Nashville, Howard County.

SALICALES

SALICACEAE

SALIX Linné

SALIX FLEXUOSA Newberry

Salix flexuosa Newberry, Later Ext. Floras 21. 1868.

Salix flexuosa Berry, U. S. Dept. Int. Geol. Surv. Professional Paper 84: 32, 109. *pl. 7. f. 14–16; pl. 11. f. 1.* 1914.

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[*] Frič, Archiv. Naturw. Landes Bohm. 4: 18, 94 1874.

Leaves narrow, linear-lanceolate in outline, equally pointed at both ends, short petioled, 5–10 cm. in length and 8–13 mm. in maximum width. Margins entire. Midrib stout below, tapering above, often somewhat flexuous. Secondaries more or less remote, about ten alternate pairs, branching from the midrib at angles varying from thirty-five to forty-five degrees, camptodrome, of fine caliber, often obsolete.

This species was described by Newberry from the Dakota sandstone. Lesquereux subsequently made it one of the varieties of his *Salix proteaefolia*, although it is obviously entitled to independent specific rank. It is of rare occurrence in the Raritan formation of New Jersey, and is preëminently a species which characterizes the Magothy formation from New Jersey to Maryland, and homotaxial horizons to the southward. It is recorded in beds of Magothy age from Marthas Vineyard to the Potomac River. It occurs in the Black Creek beds of North and South Carolina, and in the Middendorf member in the latter state. In Georgia, while not especially abundant, characteristic leaves of this species are found from the base to the top of the lower Eutaw formation in the western part of the state. In Alabama it is very common at a relatively large number of localities from the base to the top of the Tuscaloosa formation. It appears to be a common form in the Bingen sand occurring in both the lower and upper members.

OCCURRENCE: Big Railroad Cut, one mile southwest of Maxwell Spur; Adams Kaolin cuts near Murfreesboro, Pike County; Mine Creek, three and one half miles north of Nashville, Howard County.

SALIX LESQUEREUXII Berry

Salix proteaefolia Lesquereux, Cret. Fl. 60. *pl. 5. f. 1–4.* 1874.
Salix Lesquereuxii Berry, Bull. Torrey Club **37**: 21. 1910.

Leaves ovate-lanceolate in outline, somewhat more acuminate above than below, variable in size, 6–12 cm. in length and 1.1–2.2 cm. in greatest width, which is usually slightly below the middle. Petiole stout, much larger than in *Salix flexuosa*, ranging up to 1.2 cm. in length. Midrib stout below, tapering above. . Secondaries numerous, sometimes as many as twenty pairs; they branch from the midrib at angles of about forty-five degrees and are parallel and camptodrome.

This is an exceedingly variable species, and Lesquereux established several varieties of which at least one, *i. e.*, var. *linearifolia*, referable to *Salix flexuosa* Newberry. Some of Lesquereux's forms are distinguishable with difficulty from the latter. In general, *Salix Lesquereuxii* is a relatively much broader, more ovate form with more numerous and better seen secondaries and a longer petiole.

This species is an exceedingly abundant Upper Cretaceous type in both the East and the West, ranging in the Atlantic Coastal Plain from the base of the Raritan formation to the top of the Tuscaloosa formation, and possibly through the Eutaw formation as well. It is abundant in the Magothy, Black Creek, and Middendorf beds. In the West it is common in the Dakota sandstone. It is one of the forms recorded by Kurtz from the Upper Cretaceous of Argentina, indicating, if the identification is correct, a very considerable migration during the early Upper Cretaceous. In Alabama it ranges from the bottom to the top of the Tuscaloosa formation.

It has not yet been discovered in the Woodbine sand of Texas but appears to have been common in the upper member of the Bingen sand of Arkansas.

OCCURRENCE: Big Railroad Cut, one mile southwest of Maxwell Spur; Adams Kaolin cuts near Murfreesboro, Pike County.

URTICALES

MORACEAE

FICUS Linné

FICUS DAPHNOGENOIDES (Heer) Berry

Proteoides daphnogenoides Heer, Phyll. Crét. d. Nebr. 17. *pl. 4.* 1866.

Ficus daphnogenoides Berry, Bull. Torrey Club 32: 327. *pl. 21.* 1905.

This species has been found to be quite variable in size, ranging in length from 11 cm. to 22 cm. and in width from 1.9 cm. to 3.7 cm. It is usually widest in the lower half of the leaf, although sometimes the base is quite narrow and the widest part is toward the middle. In all unequivocal material the upper half of the leaf is narrow and is produced as a long, slender, often recurved tip, which is one of the characteristic features of the species. This tip is strictly comparable with the "dripping points" developed on various leaves in the modern tropics where precipitation is heavy.

Ficus daphnogenoides is a widespread and common form ranging from Marthas Vineyard to Texas in eastern North America, and from Northwest Territory to Kansas and Nebraska in the Western Interior. It occurs in the Woodbine sand of northeastern Texas and in the Tuscaloosa formation of the Eastern Gulf area.

OCCURRENCE: Big Railroad Cut, one mile southwest of Maxwell Spur, Pike County.

FICUS CRASSIPES (Heer) Heer

Proteoides crassipes Heer, Fl. Foss. Arct. 3^2: 110. *pl. 31. f. 6–8a.* 1874.

Ficus crassipes Heer, *Ibid.* 6^2: 70. *pl. 17. f. 9a; pl. 24. f. 1, 2.* 1882.

Leaves entire, narrowly lanceolate in outline, about equally tapering to the acuminate apex and base. Length 12–20 cm. Greatest width, which is in the middle part of the leaf, 1.8–2.5 cm. Texture coriaceous. Midrib stout, often extraordinarily so. Secondaries thin, open, ascending, camptodrome.

This species was described originally from the Atane beds of western Greenland, the first rather fragmentary specimens collected suggested a relationship with the genus *Proteoides*. Subsequently the original describer referred it to *Ficus*, where it undoubtedly belongs. Lesquereux has recorded it from the Dakota sandstone and it is common in the Magothy formation of the northern Atlantic Coastal Plain, and in the Black Creek formation of North Carolina. It persists into the Eutaw formation of Georgia and is especially common in the Middendorf beds of South Carolina. It is not especially common in the Tuscaloosa formation, and is a species which is especially characteristic of the post-Raritan and pre-Montana horizons of eastern North America. It has not yet been discovered in the Woodbine sand of Texas but is present in both the lower and upper members of the Bingen sand of Arkansas.

OCCURRENCE: Big Railroad Cut, one mile southwest of Maxwell Spur; Adams Kaolin cuts near Murfreesboro, Pike County;

Mine Creek, three and one half miles north of Nashville, Howard County.

FICUS OVATIFOLIA Berry (?)

Ficus ovata Newberry, Mon. U. S. Geol. Surv. **26**: 70. *pl.* 24. *f.* 1–3. 1896. Not Don, 1802–3.

Ficus ovatifolia Berry, Bull. Torrey Club **36**: 253. 1909.

Leaves ovate in outline, extended above into a narrow, usually pointed apex. Length 8–12 cm. Greatest width, which is in the basal part of the leaf, 4–7 cm. Base broadly rounded and in many specimens slightly decurrent. Margins entire. Primaries, three from the base, the midrib somewhat stouter than the lateral primaries. Secondaries camptodrome.

This species is closely allied to the Raritan species *Ficus Woolsoni* Newberry, differing primarily in its greater elongation and in the tendency of the former to a cordate outline. *Ficus ovatifolia* was described originally from the Raritan formation of New Jersey. It is present in the Black Creek formation of North Carolina and in the Eutaw formation in Georgia and Tennessee. The Bingen material is fragmentary and not certainly identified.

OCCURRENCE: Mine Creek, three and one half miles north of Nashville, Howard County.

RANALES

RANUNCULACEAE (?)

DEWALQUEA Saporta & Marion

Dewalquea insigniformis sp. nov.

Leaves digitate, of probably five leaflets. Leaflets linear-acuminate with prominently serrate margins. Length about 12 cm. Maximum width mostly 1–1.25 cm., at or slightly above the middle. Base very gradually narrowed and with entire margins for a distance of about 2 cm. Midrib stout, prominent on the under surface of the leaflets. Secondaries numerous, diverging from the midrib at angles of from thirty to forty degrees, long ascending and eventually camptodrome, sending off small outwardly directed branches to the marginal teeth. Texture coriaceous. [FIGS. 6, 7.]

This characteristic new species with its coriaceous texture must have had rather stiff strict leaves in life. It adds to our flora another form of the curious genus *Dewalquea* that is such a striking element in the Upper Cretaceous and Lower Eocene. The only known American species that resembles this new form in any respect is *Dewalquea Smithi* Berry* of the Tuscaloosa and Black Creek formations. The latter is much larger with relatively broader leaflets which have less prominently serrate margins and partially craspedodrome venation.

Dewalquea insigniformis is, however, as its name indicates, very much like *Dewalquea insignis* Hosius and V. d. Marck,† a prominent species in the Campanian and Maestrichtian substages of Europe. The latter has relatively broader, less prominently toothed leaflets, sometimes as many as seven in number, and the venation is said to be craspedodrome. The latter is, however, a character of slight value since entire and toothed leaflets generally occur together and I imagine that *Dewalquea insignis* is merely a serrate form of the associated *Dewalquea haldemiana* Saporta and Marion. If the latter had prominent serrate teeth added it would be identical with *Dewalquea insigniformis*.

The latter is represented by a large number of fragmentary specimens from the upper member of the Bingen sand the most perfect of which is shown in solid black in the accompanying figure.

OCCURRENCE: Big Railroad Cut, one mile southwest of Maxwell Spur; Adams Kaolin cuts near Murfreesboro, Pike County.

MAGNOLIACEAE

LIRIODENDRON Linné

LIRIODENDRON MEEKII Heer

Liriodendron Meekii Heer; Meek & Hayden, Proc. Phila. Acad. Sci. 10: 265. 1858; Phyll. Crét. d. Nebr. 21. *pl. 4. f. 3, 4.* 1866.

Leaves of relatively small size, more or less panduriform in outline (described by Newberry as three-lobed with the median lobe emarginate). Length along the midrib 5–10 cm., usually about 5 cm., the Alabama specimen being 4.7 cm. Greatest width, which is toward the base of the leaf, 2.4–7 cm., averaging about 4 cm., the Alabama specimen being 4.3 cm. Lobes more or less well marked, the basal pair directed laterally, and broadly rounded, the upper pair directed diagonally, usually less well marked, rounded at the outside and inclined toward angularity at the tip. Lateral sinuses more or less indented in the typical forms, such as the Alabama specimen figured, extending nearly half way to the midrib and broadly rounded. Apical sinus wide and open, usually cuneate in outline. Base somewhat descending close to the midrib, broadly and somewhat curved-cuneate. Midrib stout, straight, or somewhat curved. Secondaries thin, parallel, about six pairs branching from the midrib at angles of over 45 degrees and gently curving upward toward their extremities, probably camptodrome, their ultimate course not made out.

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* Berry, E. W. Torreya 10: 34–38. *f. 1.* 1910.

† Hosius & V. d. Marck. Palaeontographica 26: 172. *pl. 32. f. 111–113; pl. 33 f. 109; pl. 34. f. 110; pl. 35. f. 123.* 1880.

The mid-Cretaceous leaves, variously described as *Liriodendron Meekii*, *L. primaevum*, *L. semialatum*, and *L. simplex*, are in a state of almost hopeless confusion, due largely to the difficulty of determining the specific lines of cleavage in a probably genetic and variable series of forms.

Liriodendron Meekii was described by Professor Heer in 1858, from the Dakota sandstone of Nebraska, in an appendix to a paper by Meek and Hayden. It was described as trilobate and was figured, but was compared with the European *Liriodendron Procaccinii* Unger and with the living *Liriodendron Tulipifera* Linné. In 1866 the same author returns to this subject, figuring the two well-known specimens, which figures have been reproduced by both Lesquereux and Newberry. It would seem that this form must be considered as the type of this species and the present writer so considers it. However, Heer, in describing the Atane flora of Greenland in 1882, in returning to this subject, considers this form, as well as various simple emarginate *Liriodendropsis*-like forms, as different varieties of *Liriodendron Meekii*, and in this he was subsequently followed by Lesquereux, but not by Newberry, who insisted upon the distinctness of the lobate form. We find one of these varieties of Heer's *Liriodendron Meekii genuina* which may belong here, although the leaves are exceptionally large and poorly preserved. Another variety, *Liriodendron Meekii primaeva*, includes the slightly lobate forms subsequently referred to *Liriodendron primaevum* Newberry. It would seem that the small entire retuse leaves which have been variously referred to *Leguminosites*, *Bumelia*, *Bignonia*, *Liriodendron Meekii*, and *L. primaevum*, as well as to *Liriodendron simplex* and to the genus *Liriodendropsis*, are more probably allied to the Leguminoseae than to *Liriodendron*, and they are so considered in the present study. On the other hand, *Liriodendron Meekii* is restricted to include only such lobate forms as do not seem to be specifically distinct from the originally figured types, and with them are merged those forms usually referred to *Liriodendron primaevum* Newberry, which are simply variants of the type just mentioned with less prominently developed lobes.

As here delimited the species is found in the Dakota sandstone, in the Raritan formation, or possibly the Magothy formation (morainic material) on Staten Island, somewhat doubtfully in the Atane beds of Greenland, doubtfully in the lower part of the Black Creek formation of North Carolina,* positively in the lower part of the Alabama Tuscaloosa, and doubtfully in the South American Cretaceous and in the Cenomanian of Saxony.

OCCURRENCE: Big Railroad Cut, one mile southwest of Maxwell Spur, Pike County.

LIRIODENDRON QUERCIFOLIUM Newberry

Liriodendron quercifolium Newberry, Bull. Torrey Club 14: 6. *pl. 62. f. 1.* 1887; Fl. Amboy Clays, 81. *pl. 51. f. 1–6.* 1896.

Leaves oblong in general outline, of large size, pinnately divided by narrow sinuses into from two to four lateral lobes. Apex emarginate. Base truncate to somewhat cordate. Length along the midrib 7–9 cm. and probably considerably greater in some specimens since one fragment measures 12 cm. in width. Width in perfect specimens about 9 cm. Lateral lobes ovate in outline with very acute tips, sometimes narrowed proximad giving them an almost obovate outline; intervening lateral sinuses narrow and deeply cut, in some instances reaching nearly to the midrib, rounded.

In some specimens only two main lobes are developed on each side, which are then quite similar to the typical modern leaf. In these cases, however, the upper lobes are divided by a shallow sinus into two sharp lobules. Other specimens show three lobes of equal magnitude on each side, while one of the best specimens has four nearly equal lobes on each side, the basal and apical pairs being somewhat shorter than the medial pairs. This form of leaf is very suggestive of some species of *Quercus*, but its variations, as well as its venation, show that it is related to *Liriodendron*. The petiole is preserved for a considerable length and is very stout, as is the midrib. There is one main secondary traversing each lobe and running directly to its apical point. In addition there are one or more camptodrome secondaries in each lobe which anastomose with branches from the main secondary, their number being dependent upon the relative width of the lobe; they branch from the midrib at angles of about sixty degrees.

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* Berry, Bull. Torrey Club 34: 197. 1907.

At first sight this species appears to differ considerably from *Liriodendron oblongifolium* and from the modern form, but this difference is not nearly as great as it seems, and it is probable that *Liriodendron quercifolium* is simply a variation from the common ancestor of the two species in the direction of *Liriodendron pinnatifidum* Lesq. Numerous leaves of the modern tree can be found with an incipient lobation suggesting *Liriodendron quercifolium*. In these, however, the sinus is comparatively shallow and rounded, so that the general appearance of the two is not markedly similar.

OCCURRENCE: Mine Creek, three and one half miles north of Nashville, Howard County.

MENISPERMACEAE

MENISPERMITES Lesquereux

Menispermites integrifolia sp. nov.

Leaves deltoid-ovate in outline, with a short sharply pointed apex and a truncate or slightly cordate peltate base. Length about 6.5 cm. Maximum width, in the basal part of the leaf, about 6.5 cm. Margins entire, full and rounded. Texture subcoriaceous. Petiole missing. Midrib stout, enlarges proximad. Lateral primaries subopposite, suprabasilar, but slightly differentiated from true secondaries, of which they constitute the second pair: they diverge from the midrib at angles of about forty-five degrees or slightly more, are relatively straight for more than half of the distance to the margin where they curve upward and are eventually camptodrome. Secondaries well marked, four or five opposite to alternate pairs, irregularly spaced, one pair below the primaries, camptodrome. Primaries give off on their outer sides, three to five curved camptodrome laterals. Tertiaries thin percurrent with occasional laterals from midrib parallel with secondaries.

The present species is not at all trilobate as are some of the Dakota sandstone species, from which it also differs in having camptodrome instead of craspedodrome lateral primaries. Among described forms it is like some of the New Jersey Raritan leaves that Newberry referred to *Menispermites borealis* Heer, without greatly resembling the type material of the latter species. The most similar figured form is Newberry's *pl. 50. fig. 2*, Fl. Amboy Clays, which differs from the present species in its inequilateral form. Superficially *Menispermites integrifolia* suggests the associated *Cordia apiculata* (Hollick) Berry, differing especially in its peltate base. It may be also compared with various Upper Cretaceous leaves commonly referred to *Populus*, some of which have been referred by various students to *Cocculus*. The latter genus seems to be the closest to the fossil but in view of the uncertainty of such a reference *Menispermites* will serve equally well as a generic designation for leaves of the family Menispermaceae.

The present species is represented by incomplete specimens in the upper member of the Bingen sand which it is inadvisable to figure. The foregoing description is based on the complete type material from the Tuscaloosa formation of Alabama which will be figured in a report on the Cretaceous Floras of the Eastern Gulf region now going through the press of the United States Geological Survey.

OCCURRENCE: Big Railroad Cut, one mile southwest of Maxwell Spur, Pike County.

ROSALES

LEGUMINOSAE

COLUTEA Linné

COLUTEA PRIMORDIALIS Heer

Colutea primordialis Heer, Fl. Foss. Arct. 6^2: 99. *pl. 27. f. 7–11; pl. 43. f. 7, 8.* 1882.

This species was described from the Atane beds of west Greenland and subsequently recorded from the Dakota sandstone of Kansas, the Raritan formation of New Jersey, and the Magothy formation of Marthas Vineyard, Long Island and Maryland. It is represented by a single specimen in the collection from the upper member of the Bingen sand.

OCCURRENCE: Big Railroad Cut, one mile southwest of Maxwell Spur, Pike County.

LEGUMINOSITES Bowerbank

LEGUMINOSITES OMPHALOBIOIDES Lesquereux

Leguminosites omphalobioides Lesquereux, Mon. U. S. Geol. Surv. 17: 149. *pl. 38. f. 4.* 1892.

Leaflets elliptical in outline, 3.2–4 cm. in length by 1.5–1.7 cm. in greatest breadth, which is about half-way between the apex and the base. Texture subcoriaceous. Apex rather broadly rounded. Base slightly narrowed and decurrent to the point of attachment. Lesquereux speaks of a short petiole, but this is lacking in his type figure and in all the specimens examined by the writer. The midrib is not especially wide, but is quite prominent. The secondaries are thin and alternate; they number about six pairs, and branch from the midrib at angles of fifty degrees, or somewhat less, curving upward close to the margins, camptodrome.

This species was described originally from the Dakota sandstone of Kansas, and subsequently found in the Magothy formation of Maryland and the Tuscaloosa formation of Alabama. It is represented by a single, but characteristic specimen in the collection from the upper member of the Bingen sand.

OCCURRENCE: Big Railroad Cut, one mile southwest of Maxwell Spur, Pike County.

GERANIALES

EUPHORBIACEAE

MANIHOTITES Berry

MANIHOTITES GEORGIANA Berry

Manihotites georgiana Berry, Bull. Torrey Club 37: 507. *f. 1, 2.* 1910; U. S. Dept. Int. Geol. Surv. Professional Paper 84: 114. *pls. 22; 23; 24. f. 4, 5.* 1914.

Leaves of extraordinarily large size, 36–48 cm. across, palmately and deeply lobate, the main lobes dichotomously sublobate. Base missing, probably peltate. Margins entire, more or less undulate. Texture coriaceous. Venation coarse. Five or six stout primaries diverge at acute angles from the top of the petiole and fork dichotomously about 5–6 cm. above their base at angles of thirty to fifty degrees. These branches may again fork dichotomously in a distance of 4–6 cm., or may not give off any branches, or the branches may be clearly subsidiary in size and run to the apex of a subordinate lobe. There are a sparse number of relatively fine secondaries, which diverge at angles of about forty-five degrees or more and are apparently camptodrome. In each of the large specimens a straight vein of secondary size runs directly to the base of a single main sinus. It is possible that this vein diverges along the margin in a vein which forms a marginal hem, as in the sinuses of lobed sassafras leaves, but such a vein can not be made out, although at one point there is such a marginal vein connected with the main venation by straight transverse tertiaries. Deep and narrow but rounded sinuses approach within 3–5 cm. of the base and divide the leaf into five or more major lobes; these are subdivided by more or less deep sinuses of a similar character into inequilateral, ovate lanceolate, obtusely pointed subordinate lobes.

This remarkable species was described from perfect material from the lower Eutaw of western Georgia although the leaves are so large that it is usually represented by fragmentary specimens. It occurs in the Eutaw and Ripley of western Tennessee, in the Ripley of Georgia and in the Black Creek formation of North Carolina. Several broken specimens have been collected from the upper member of the Bingen sand.

OCCURRENCE: Big Railroad Cut, one mile southwest of Maxwell Spur, Pike County.

SAPINDALES

SAPINDACEAE

SAPINDUS Linné

SAPINDUS MORRISONI Heer

Sapindus Morrisoni Heer, Fl. Foss. Arct. 6²: 96. *pl. 40. f. 1; pl. 41. f. 3; pl. 43. f. 1a, b; pl. 44. f. 7, 8.* 1882; Ibid. 7: 39. *pl. 65. f. 5.* 1883.

Leaflets of variable, usually large size, lanceolate and more or less inequilateral in outline, with a broadly cuneate or rounded base and a pointed tip. Petiolulate. Texture subcoriaceous.

Margins entire. Midrib stout, curved. Secondaries numerous, camptodrome.

The present species was described originally by Heer, to whom it must be credited, from west Greenland although based on Lesquereux's manuscript which appeared in print the following year. It is common in the Dakota sandstone and in the Magothy formation of the northern Atlantic coastal plain and occurs in the Woodbine formation of the Western Gulf area, and the Tuscaloosa formation of the Eastern Gulf area. Not uncommon in both the lower and upper members of the Bingen sand.

OCCURRENCE: Big Railroad Cut, one mile southwest of Maxwell Spur, Pike County: Mine Creek, three and one half miles north of Nashville, Howard County.

THYMELEALES

LAURACEAE

CINNAMOMUM Blume

CINNAMOMUM NEWBERRYI Berry (?)

Cinnamomum intermedium Newberry, Fl. Amboy Clays, 89. *pl. 29. f. 1–8, 10.* 1896. Not Ettingshausen.

Cinnamomum Newberryi Berry, Bull. Torrey Bot. Club **38**: 423. 1911.

This widespread species has a considerable geological as well as geographical range. Found from western Greenland to Kansas, Iowa and Alabama it ranges from the lower Raritan upward to the lower Eutaw. It is common in the lower Tuscaloosa of western Alabama and is only doubtfully identified from the lower member of the Bingen sand.

OCCURRENCE: Mine Creek, three and one half miles north of Nashville, Howard County.

ERICALES

ERICACEAE

ANDROMEDA PARLATORII Heer

Andromeda Parlatorii Heer, Phyll. Crét. d. Nebr. 18. *pl. 1. f. 5.* 1866.

The species is found from Greenland to Nebraska and Alabama, and from the Raritan upward to the Black Creek formation. It is common in the Tuscaloosa formation of western Alabama but has not heretofore been collected from the Upper Cretaceous of the Western Gulf area. It is present in the lower, but has not as yet been recognized in the upper member of the Bingen sand.

OCCURRENCE: Mine Creek, three and one half miles north of Nashville, Howard County.

ANDROMEDA NOVAE-CAESAREAE Hollick

Andromeda novae-caesareae Hollick; Newberry, Mon. U. S. Geol. Surv. **26**: 121. *pl. 42. f. 9–12, 28–31.* 1896; Berry, U. S. Dept. Int. Geol. Surv. Professional Paper 84: 58, 120. *pl. 14. f. 5, 6; pl. 24. f. 1.* 1914.

Leaves small, thick, and entire, with stout petioles and midribs and obscure secondary venation which is immersed in the thick lamina. Length 2.5–5.0 cm. Width varying from 0.9–1.3 cm. Venation, where visible, showing numerous parallel, camptodrome, relatively long and thin secondaries which branch from the midrib at acute angles. While the majority of these leaves are equally acuminate at both ends there is considerable variation in this respect, and a well-marked tendency is shown in a considerable number of specimens which are relatively broader, especially in the upper half, toward an obtusely rounded apex, the termination of the midrib showing as a small mucronate point. The base in these forms gradually narrows to the stout petiole.

This species is found as early as the uppermost Raritan in the New Jersey area and is also common in the everlying Magothy. It is exceedingly common throughout the Black Creek formation of the Carolinas and has also been recorded from the Cusseta sand member of the Ripley formation in Georgia, and from the Eutaw formation of Tennessee. It occurs also in the Woodbine of Texas and the Tuscaloosa of Alabama so that it is apparently a form with a wide stratigraphic range.

OCCURRENCE: Mine Creek, three and one half miles north of Nashville, Howard County.

POLEMONIALES

BORAGINACEAE

CORDIA Linné

CORDIA APICULATA (Hollick) Berry

Populus apiculata Hollick, Trans. N. Y. Acad. Sci. **12**: 4. *pl. 3. f. 2.* 1892.

Cordia apiculata Berry, Md. Geol. Surv. Upper Cretaceous, 897. *pl. 90. f. 6.* 1916.

Leaves variable in size and shape, ovate to orbicular in general outline, 5–10 cm. in length by 3–7 cm. in maximum width, which is at or below the middle. Apex usually somewhat abruptly produced into an acuminate tip. Base cuneate and slightly decurrent to rounded or almost truncate. Margins entire, sometimes slightly repand. Petiole of medium length, stout. Midrib mediumly stout, often flexuous. Secondaries five or six pairs, subopposite below, alternate above, slender, branching from the midrib at angles of from forty-five to fifty degrees and arching upward, camptodrome. Tertiaries camptodrome in the marginal region, percurrent internally.

This species in all its characters suggests most strongly the existing *Cordia sebestena* Linné which ranges from the Florida Keys to New Guinea. It also suggests *Cordia tremula* Griesbach of the West Indies, and there is a general generic likeness to various other existing species of this genus. *Cordia* leaves are variable and tend to have more or less toothed margins as is sometimes the case in *Cordia sebestena*, but they are in general entire or slightly repand, and like the fossil somewhat variable. *Cordia* is certainly represented in the Lower Eocene flora of the Gulf region by forms that may be descendants of this Upper Cretaceous species. The present form has been recorded from New Jersey, Staten Island, Long Island, and Delaware, and is not rare in the lower beds of the Tuscaloosa formation in the Alabama region.

Represented by a single specimen in the present collection from the upper member of the Bingen sand.

OCCURRENCE: Big Railroad Cut, one mile southwest of Maxwell Spur, Pike County.

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Explanation of plate 4

SEQUOIA CONCINNA Heer

FIG. 1. Foliage from the Bingen sand.
FIG. 2. Cone from the Bingen sand..
FIGS. 3-5. Heretofore unfigured cones from the Magothy formation at Cliffwood Bluff, New Jersey.

DEWALQUEA INSIGNIFORMIS Berry

FIG. 6. Showing the leaf habit.
FIG. 7. Showing venation, × 3.

Notes on the genus Herberta, with a revision of the species known from Europe, Canada and the United States*

ALEXANDER W. EVANS

(WITH PLATE 8 AND 29 TEXT FIGURES)

INTRODUCTION

The genus *Herberta* (or *Herbertus*, as it was originally spelled) was published by S. F. Gray in 1821.† It was named in honor of George Herbert, one of the patrons of Micheli, and was based on a single species, the *Jungermannia adunca* of Dickson. In common with Gray's other genera, *Herberta* was ignored by botanical writers until Carruthers called attention to it in 1865.‡ Although it has since been accepted more or less widely in both Europe and North America, a strong tendency has recently arisen to repudiate it. This is largely due to Gray's unfortunate practice of giving his generic names a masculine termination, even when he derived them from the names of persons. As Dumortier expresses it, they are the names of men and not of plants. Since, however, a change from a masculine to a feminine termination might readily be construed as the correction of an error in orthography, this objection seems hardly sufficient to justify the setting aside of Gray's genera altogether. From a scientific standpoint the claims of *Herberta* are fully as good as those of many other genera which are accepted without question, and the writer is therefore disposed to recognize it, at least for the present.

A year after the appearance of *Herberta*, Dumortier§ published his genus *Schisma*, including under it not only *J. adunca* but also *J. juniperina* Sw. and *J. concinnata* Lightf. Nine years later he added another species, *S. stramineum* Dumort.,‖ but excluded *J. concinnata*, making it the type of his new genus *Acolea*. At that time he was undoubtedly ignorant of Gray's writings. Many years afterwards, however, in his last published work on the Hepaticae,* he quotes Gray's generic names as synonyms, refusing to recognize them as valid on account of their masculine form. In the present instance he naturally maintains his genus *Schisma*. Gray's genera were likewise unknown to Nees von Esenbeck. In the first volume of his Naturgeschichte der europäischen Lebermoose, published in 1833, he accepted *Schisma* as valid (p. 107). In the third volume, published in 1838, he suggested that it might be considered a section of his genus *Mastigophora* (p. 573), although he continued to employ *Schisma* as a generic name. The inclusion of *Schisma* under *Mastigophora* would have been quite unwarranted on the basis of priority. The latter genus was not published until 1833, and its characters were completely revised in 1835. *Schisma* therefore antedates it by more than a decade. As originally defined *Mastigophora* was essentially the equivalent of the genus *Lepidozia* Dumort., although no species were definitely assigned to it; in its revised form it was made to include such species as *Jungermannia diclados* Brid. and *J. Woodsii* Hook. At the present time it is accepted by most writers in its revised form.

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* Contribution from the Osborn Botanical Laboratory.

† Nat. Arr. British Pl. 1: 705. 1821.

‡ Jour. Bot. 3: 300. 1865.

§ Comm. Bot. 114. 1822.

‖ Syll. Jung. 76. 1831.

Nees von Esenbeck's provisional reduction was adopted definitely by the authors of the Synopsis Hepaticarum (1845), who went even farther than he and included both *Schisma* and *Mastigophora* under the genus *Sendtnera* of Endlicher,† a genus which had been proposed a few years earlier for the single species *Jungermannia Woodsii*. On account of the high position which the Synopsis holds in the literature of the Hepaticae the name *Sendtnera* was acknowledged for many years as the correct name for the combined genus. Now, however, both *Schisma* and *Mastigophora* are universally regarded as distinct, and the name *Schisma* is employed by those who refuse to sanction the use of the name *Herberta*.

Of the eighteen species of *Sendtnera* given in the Synopsis only six would now be included in the genus *Herberta*. In Stephani's recent monograph of the genus (under the name *Schisma*), published in 1909,* seventy-one species are recognized. According to the information at hand four species have since been described, making seventy-five in all. This marked increase is due partly to the more extensive material at the disposal of recent writers and partly to their narrower interpretation of species. Of the seventy-one species admitted by Stephani nearly all have a very limited geographical range and no fewer than forty-seven are described as new. Taking into account the species of his monograph and those since published, two are restricted to Europe, thirteen to Africa (including the Azores), sixteen to Asia (including the Philippines), seven to various islands of the Pacific, ten to tropical North America, and twenty-six to South America; Stephani gives one species a wider range, including Samoa, Tahiti, Hawaii, Japan, and Himalaya. It is interesting to note that he accredits no species to North America north of Mexico, although *H. adunca*, a species which he restricts to Europe, has been repeatedly reported by American writers, not only from Alaska and British Columbia but also from the eastern United States.

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* Bull. Soc. Bot. Belgique 13: 123. 1874.

† Gen. Plant. 1342. 1840.

The species of *Herberta* grow on rocks, on trees, and on the ground and sometimes form extensive mats or tufts. In the tropics they seem to be confined to higher altitudes, but the few species which occur in temperate and frigid regions sometimes descend to the level of the sea, this being true in both hemispheres. The plants are usually marked by a yellowish or brownish color, due to a pigmentation of the cell walls. In rare cases a reddish or purplish tinge is present, and in sheltered stations the pigmentation may be so slight that the plants appear green.

NOTES ON THE MORPHOLOGY OF THE GENUS

In its morphological features *Herberta* is one of the most clearly defined and natural genera of the Hepaticae. The gametophyte consists of a prostrate rhizome which gives rise to numerous secondary stems. These sometimes remain simple, even when they become comparatively long, and sometimes branch sparingly. The subequally bifid leaves are slightly incubous while the underleaves are strictly transverse, and yet, since the underleaves are nearly or quite as large as the leaves and similar to them in most other respects, the shoots appear almost radial in structure. The inflorescence is invariably dioicous. The androecium is at first terminal on a secondary stem or one of its branches but soon proliferates, and the male shoot eventually shows a series of short intercalary androecia separated by equally short sections bearing normal leaves. The archegonia are likewise terminal on secondary stems. When fertilization takes place the growth of the female stem is usually brought to an end; when fertilization does not take place one or more subfloral innovations may be produced. The involucre is composed of crowded bracts and bracteoles, which are essentially alike and not very different from the leaves, while the perianth is deeply laciniate at the mouth and free or nearly so from the bracts. The calyptra and the sporophyte conform to the usual jungermanniaceous type.

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* Spec. Hepat. 4: 1–30. 1909

The rhizome of *Herberta* was apparently overlooked by the older writers. Spruce,* however, calls attention to it and to the fact that it may bear rhizoids, while Stephani mentions its small diameter and copious branching. It tends, in fact, to be considerably more slender than the secondary stems, although both vary in size. In *H. juniperina*, for example, an average rhizome measures only 0.35 × 0.25 mm. in cross section, while a stem measures 0.5 × 0.35. The features of the rhizome are not easily made out in material where the secondary stems are well developed. The leaves are more or less disintegrated with age and it is difficult to demonstrate the relationship between the branches and the leaves. In most cases the leaves and underleaves are minute and widely separated. The leaves are practically transverse in their insertion and it would be difficult to distinguish them from the underleaves, if the rhizome did not show a slight dorsiventral flattening, the underleaves being of course situated on one of the flattened sides. Both leaves and underleaves are distinctly bifid. The rhizoids grow out normally from the basal cells of the underleaves, although they often occur on the leaves as well, but the rhizome itself is usually free from them. The branches are all intercalary and many of them spring from the axils of the underleaves. This position, however, is not constant; occasional branches tend to be lateral and do not show a definite relationship to either leaves or underleaves. It is of course possible that their aberrant position is due to secondary displacements caused by inequalities of growth, but this could not be definitely determined from the material studied. The secondary stems are sometimes direct extensions of the creeping rhizomes, but it is usually possible to demonstrate their origin as branches. Even under these circumstances they usually bear small leaves at the base and only gradually give rise to the normal leaves. Sometimes the change is more abrupt, and all gradations may be present between the small-leaved prostrate rhizomes and the typical secondary stems with large leaves.

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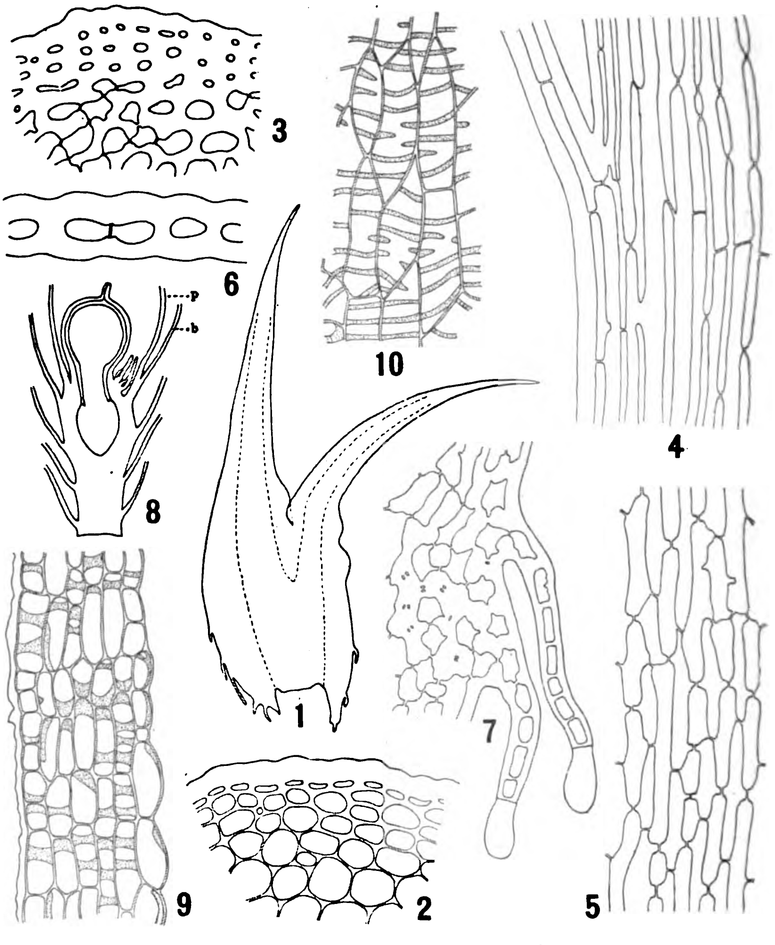
* Trans. Bot. Soc. Edinburgh 15: 340. 1885.

The secondary stems differ greatly in length in different species and even in the same species under varying conditions. In some of the robust tropical species a length of 25 cm. may be attained. The stems are usually ascending but are often pendulous and sometimes form conspicuous festoons hanging from the branches of trees. The branches are always intercalary, just as in the case of the rhizomes. The normal vegetative branches take their origin in the axils of underleaves and are rarely subdivided. In most cases they spread widely and show a flagelliform appearance, their leaves being distinctly smaller than those of the stem. When the growing point of a stem is injured, however, a ventral branch sometimes changes its direction of growth and assumes that of the stem, its leaves at the same time increasing in size. The same thing is true of the subfloral innovations, which may be either ventral or lateral in position. The growth of the stem is here brought to an end by the development of the archegonia. Rhizoids are often absent altogether from the secondary stems. When they occur they are usually restricted to the underleaves and leaves of the ventral branches, although the normal leaves and underleaves have the power of developing them.

The leaves (TEXT FIGS. 1, 14, 15, 21–25) and underleaves of the secondary stems present a great deal of uniformity throughout the genus. They are more or less deeply bifid with a narrow sinus and sharp divisions. In rare cases a leaf may be trifid instead of bifid, a peculiarity to which certain species seem to be more subject than others. The divisions are sometimes distinctly grooved but show little tendency to be complicate, both lying approximately in



FIGS 1–10. HERBERTA JUNIPERINA (Sw.) Trevis.

1. Leaf, × 17. 2. Transverse section of a young stem, × 225. 3. Transverse section of a mature stem, × 225. 4. Longitudinal section of a mature stem, including the base of a leaf, × 225. 5. Cells from the basal vitta of a leaf, × 225. 6. Cells from the basal vitta of a leaf in transverse section, × 300. 7. Cells from the dorsal base of a leaf, showing cilia with slime papillae, × 225. 8. Longitudinal section of a young sporophyte and surrounding parts, × 17; *b*, innermost perichaetial bract; *p*, perianth. 9. Transverse section of the wall of a mature capsule, × 225. 10. Cells from the innermost layer of the wall of a mature capsule, × 225. FIGS. 1, 5–7 were drawn from specimens collected by the writer on Blue Mountain Peak, Jamaica, *242*; FIGS. 2–4, 6, from specimens collected by L. M. Underwood along the trail from Cinchona to Morce's Gap, Jamaica, *280*; the remaining figures, from specimens collected by W. Harris on the lower slopes of Sir John Peak, Jamaica, *11133*.

the same plane. At the base on each side a series of slime papillae or their vestiges can be demonstrated. These are sometimes sessile (TEXT FIG. 17) and sometimes borne on the tips of more or less evident teeth or cilia (TEXT FIG. 7; PLATE 8, FIG. 5). Occasionally slime papillae with their teeth are developed on the surfaces of the leaves and underleaves, as well as on their margins. The teeth vary from short stalks a cell or two long to broad and subdivided lobe-like structures. Except for the basal teeth associated with the slime papillae the margins are usually quite entire. In a few species, however, distinct teeth are present higher up, even beyond the region of the sinus, and these teeth show no evidences of slime papillae. Even when teeth of this character are present the upper parts of the divisions lack them completely. A vague serrulation, caused by projecting cells, may sometimes be discernible but seems to be a very exceptional feature.

Aside from the difference in insertion there are certain other slight differences between the leaves and underleaves. The leaves are usually curved backward and appear unsymmetrical when dissected from the stems and spread out flat. The curvature affects the ventral division more strongly than the dorsal division (PLATE 8, FIGS. 1–3); the latter in fact may be straight or nearly so while the ventral division is strongly curved (TEXT FIG. 1). In some species the curvature is much less pronounced than in others and may not be evident at all in explanate leaves (TEXT FIGS. 22–25); the lack of symmetry, however, still expresses itself in a difference of direction of the divisions and in a greater development of the basal portion on the dorsal side. The underleaves bend backward in a squarrose fashion and appear symmetrical when spread out, their straight divisions diverging equally and the basal portion being equally developed on the two sides. The leaves and underleaves are usually more or less imbricated. The divisions of the curved leaves and squarrose underleaves are thus crowded together along the ventral portion of the shoot, the plant acquiring a distinctly moss-like appearance.

The cells and especially the cell-walls yield some of the most distinctive characters of the genus. Most of the walls are strongly thickened and this applies even to the rhizoids when they become old. According to Goebel* excessive thickening of the cell walls in the bryophytes, which occurs especially in xerophilous species, is significant on account of the great power of imbibition which these walls possess. They readily absorb and retain water, and the rapidity with which most species of *Herberta* regain their normal appearance and consistency, when a dry tuft is deluged with water, is a striking phenomenon. In the cauline portions of the plant the cells are all elongated, although they never assume a truly prosenchymatous character. The outer or cortical region is distinguished from the inner or axial region by its deeper color and more strongly thickened walls. In the secondary stems the thickening at first takes place in the outermost layer of cells, the process continuing until the cell cavities become reduced to narrow canals (TEXT FIG. 2). The thickening is largely restricted to the outer or superficial walls and the layer presents the appearance of an epidermis with well-developed cuticle. In some cases the entire cortex consists of this outermost layer, the walls of the remaining cells showing only a slight degree of thickening (TEXT FIG. 26). This, however, is very unusual. In the majority of cases two or more additional layers take part in the formation of the cortical region; their walls become as markedly thickened as those of the outermost layer, the only difference being that the thickening is deposited uniformly on all the walls (TEXT FIG. 3). Even in the central region the thickening of the walls is sometimes very pronounced, though never so much so as in the cortical region. Since, moreover, the central cells are larger than the cortical cells, their cavities remain distinctly wider. The cells of the stem are everywhere connected by pits, which show clearly in both transverse and longitudinal walls (TEXT FIGS. 3, 4). They are just as evident in the superficial layer as elsewhere, the cells of this layer being connected with one another both longitudinally and tangentially, as well as with the cells of the layer next within. There is nothing, in fact, to indicate any essential difference in function between the superficial layer and the other cortical layers. In spite of the fact that the outer walls simulate a cuticle so strongly, they have the same powers of imbibition as the other walls and simply form part of the imbibing system of the stem. In the rhizomes the same distinction between cortical and central regions is apparent. There is perhaps a tendency for the cortical region to be thinner and for the cell-walls of the central region to be less thickened than in the secondary stems, but there are no essential differences between the two.

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* See Organographie der Pflanzen, 2d ed. 553. 1915.

The leaf-cells in their more important features have long been familiar to students of the Hepaticae. Although forming a single layer as in most of the Jungermanniaceae the cells show a differentiation into elongated cells and more or less isodiametric cells (see, for example, PLATE 8, FIG. 4). The elongated cells form a median band extending from the line of insertion into the basal portion of the leaf. Somewhere below the sinus the band, or "vitta," as Stephani terms it, forks, one branch passing into each division. Here they may extend to the extreme apices or stop at a variable distance below them. The isodiametric cells form the rest of the leaf and are divided into three patches by the vitta and its branches, the two lateral patches extending from the base into the divisions on their outer sides and the median patch from the forking of the vitta into the divisions on their inner sides. Apparently the first allusion to the vitta is found in the original description of *H. dicrana* (Tayl.) Trevis.* In a critical note, quoted from Taylor, a "nerve" is spoken of which runs out into the divisions. Gottsche afterward described the vitta in other species, and Stephani lays especial emphasis on it in his recent monograph. In his opinion the vitta yields some of the best differential characters in distinguishing species. He considers the basal portion (below the forking) to be constant in size for a given species, and he finds an equal constancy in the length of the branches. Unfortunately it is not always easy to determine the exact lateral boundaries of the vitta or the points where the branches terminate in the divisions of the leaves. Although the median cells of the basal portion are markedly different from the cells near the margin of the leaf, there is sometimes a gradual transition between the vitta and the marginal portion, and a similar transition may exist between the cells of the vitta and the marginal and apical cells of the divisions. Two observers, in consequence, might obtain different results in measuring the same leaf. A case in point is found in *H. adunca*. According to Stephani the branches of the vitta come to an end below the apices of the divisions; according to K. Müller they extend to the apices. At the same time the value of the vitta from the standpoint of taxonomy must not be overlooked, and Stephani deserves credit for utilizing it.

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* Syn. Hep. 239. 1845.

The cells of the vitta present a number of interesting peculiarities, not only in their structure at maturity but also in their development, especially in the way in which the thickenings of the wall are deposited. Gottsche, in his account of *H. juniperina*,* noted some of these peculiarities many years ago, but subsequent allusions to them have been very scanty. According to Gottsche each basal cell of the leaf, after treatment with caustic potash and iodide of zinc, reveals a spiral of eight to fifteen turns representing a thickening of the secondary layer of the wall. In a later account† of the same species he gives the number of turns as fifteen to twenty-two.

By treating young leaves with potash it is easy to demonstrate the presence of the bands of thickening described by Gottsche, not only in the basal portion of the leaf but elsewhere, and they clearly represent a stage in the development of the cell wall (TEXT FIG. 11). The writer has found it impossible, however, to show that the bands form a continuous spiral. They seem to be rather in the form of separate rings or partial rings, an occasional ring being branched. When the rings are incomplete the gaps occur on the free walls of the cell and never on the vertical walls, which separate the cell from its neighbors. Even under these circumstances, however, the bands of thickening extend partially across the free walls and leave only the median portion thin throughout. The bands of one cell do not lie opposite the bands of adjoining cells but tend to alternate with them. The vertical walls show a zigzag appearance where they meet the free walls, each angle of the zigzag marking the position of one of the bands. In the irregular cells between the vitta and the margin the bands are more irregular than in the cells of the vitta and rarely if ever form complete rings. In other respects they are essentially the same.

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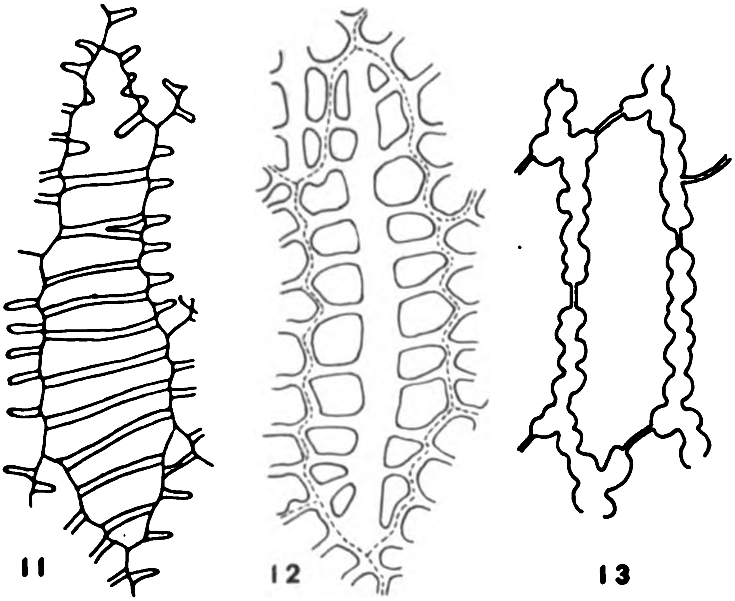
* Rabenhorst. Hep. Eur. *210*, accompanying text.

† Mex. Leverm. 138. 1863.

The bands of thickening just described soon become united by median bands laid down on the free walls (TEXT FIG. 12). These leave a series of thin places on each side, which show at first angular outlines. Almost simultaneously the bands on the vertical walls increase in thickness and become connected by deposits laid down between them, the result being that these walls acquire a continuous layer of thickening except for an occasional pit. At first the original bands are thickened more conspicuously than the intermediate regions and the vertical walls appear distinctly scalloped when examined in optical section (TEXT FIG. 13). But the conditions just described are temporary. The thin places in the free walls are gradually filled up by deposits of thickening, becoming rounded as they diminish in size, and the depressions between the scallops along the vertical walls become obliterated



FIGS. 11–13. HERBERTA JUNIPERINA (Sw.) Trevis.

11. Very young cell from the basal vitta of a leaf, surface view, × 1,000. 12. Somewhat older cell from same vitta, surface view, × 1,000. 13. Still older cell from same vitta, optical section, × 600. The figures were all drawn from specimens collected by L. M. Underwood along the trail from Cinchona to Morce's Gap, Jamaica, *280*.

in much the same way. The entire cell-cavity is eventually lined by a uniformly thick layer of deposit, the only thin places left being the pits in the vertical walls (TEXT FIGS 5, 6). Even some of the pits may be obliterated with age. When this takes place the deposit either fills the pit-chamber altogether or bridges it across, leaving a minute vestige of the chamber next to the closing membrane (TEXT FIG. 7). When the cells are mature it is sometimes possible to detect evidences of the original bands of thickening and of the scallops along the vertical walls, but the free walls present an absolutely uniform appearance. Although the thickenings look very much as if they were formed by the coalescence of trigones and intermediate thickenings, it is clear from their method of development that they are not directly comparable with the trigones and intermediate thickenings of other Hepaticae.

Although the description just drawn from *H. juniperina* probably applies in its essential features to the entire genus, the details are not always as clear in some of the other species. In *H. adunca*, for example, it is difficult to demonstrate bands of thickening except in the basal portion of the vitta, and it is doubtful if they ever form complete rings. The scalloped appearance of the vertical walls is likewise much less evident. Possibly the more indefinite conditions found are associated with the fact that the thickening of the walls in *H. adunca* is usually much less marked than in *H. juniperina.*

The leaf surface in *Herberta*, the so-called cuticle of authors, is striolate or verruculose. The roughness is sometimes very apparent and sometimes made out with difficulty. Whether differences in the degree of roughness yield constant differential characters in separating species is perhaps doubtful, although such differences seem very striking when certain species are compared.

The androecia in *Herberta* are relatively short and usually include from four to eight pairs of bracts, those at the upper and lower ends being somewhat transitional in character. The male plants tend to produce smaller leaves than female plants or vigorous sterile plants, and although the bracts are considerably larger than the leaves borne between the successive androecia, they scarcely equal in size the normal leaves on female individuals. Several years ago Schiffner made the remarkable discovery that antheridia occur not only in the axils of the bracts but also in the axils of the bracteoles.* In order to determine whether this phenomenon was widespread among the Ptilidioideae, to which group *Herberta* is usually assigned, he examined species of several other genera. The closely related *Mastigophora*, however, was the only one in which he was able to observe antheridial bracteoles. In the case of *Herberta* the bracteoles differ from the bracts in about the same way that the ordinary underleaves differ from the leaves. Both bracts (TEXT FIG. 20; PLATE 8, FIGS. 8, 9) and bracteoles are more or less imbricated and have a broad inflated pocket at the base enclosing a cluster of two or more antheridia. The pocket does not involve the entire width of the basal region but leaves a narrow flattish or revolute strip on each side. In the inflated portion the cells are broader and much paler than ordinary cells, and the thickenings of the walls are more irregular in outline and less strongly developed. The divisions, sinus, and margins are much the same as on ordinary leaves.

The perichaetial bracts (PLATE 8, FIGS. 10, 11) and bracteoles are essentially alike. They occur in three or four closely crowded series and increase somewhat in size toward the perianth, only the apical portion of which projects beyond them. Those of the innermost series, when viewed from the outer surface, show two rounded ridges in the basal portion, separated by a narrow median groove. A marginal band on each side is flat or slightly concave. The divisions are much the same as on ordinary leaves but the margins are much more toothed, the teeth being irregular and extending higher up, sometimes almost to the apices of the divisions. Occasionally minute and irregular paraphyllia (PLATE 8, FIG. 12) with marginal papillae are found among the bracts. According to Spruce the bracts closely embrace the perianth but are free from it throughout their entire length; according to Stephani they are coalescent with the perianth up to a considerable height. A longitudinal section through a young sporophyte and surrounding parts (TEXT FIG. 8) shows that Spruce was essentially correct. Any coalescence which may be present is so slight as to be practically negligible. Between the innermost bracts and bracteole and the leaves below the involucre there is a gradual transition.

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* Untersuchungen über Amphigastrial-Antheridien und über den Bau der Andröcien der Ptilidioideen. Hedwigia 50: 146–162. *f.* 1–39. 1910.

The perianth of *Herberta*, when well developed, clearly supports the theory that three floral leaves take part in the formation of this organ (PLATE 8, FIG. 13). It is split for nearly half its length into six slender laciniae, essentially like divisions of leaves, every alternate split being a little deeper than the others. These deeper splits mark the boundaries of the three coalescent leaves. In the undivided portion of the perianth a cross section shows that six rounded ridges are present, separated by six rounded grooves (PLATE 8, FIG. 14). Three alternate grooves are deeper than the others and correspond with the three deeper splits at the mouth of the perianth. The innermost bracts and bracteoles, each with its two dorsal ridges separated by a groove, are closely appressed to the ridges and grooves of the perianth. The laciniae of the perianth bear numerous slime-papillae and often teeth. The slime papillae occur not only along the margins of the laciniae toward the base but also on the inner surface of the perianth. Here they sometimes form short rows and sometimes show no regular arrangement. The surface papillae are occasionally borne on the tips of short teeth or along the margins of narrow and irregular ridges. In some cases the perianth is not developed normally. More than six laciniae, for example, may be present at the mouth, or one of the splits may extend to the very base; sometimes both of these abnormalities may be seen in a single perianth. An increase in the number of laciniae is not surprising, since ordinary vegetative leaves with three divisions sometimes occur, and the deep split might plausibly be interpreted as a place where coalescence had failed to take place.

The wall of the capsule is described in its essential features by Spruce. It is composed of from five to seven layers of cells (TEXT FIG. 9) and shows a thickness of 70–100 μ. This is considerably more than in most of the leafy Hepaticae studied by Andreas.* In *Plagiochila asplenioides* (L.) Dumort., for example, where the wall is composed of seven or eight layers, the thickness is only 55 μ, while in *Chiloscyphus polyanthus* (L.) Corda, where the wall is composed of five layers, the thickness is only 25 μ. It is less, however, in *Herberta* than in *Pleurozia purpurea* (Lightf.)

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* Ueber den Bau der Wand und die Oeffnungsweise des Lebermoossporogons. Flora 86: 161–213. *pl. 12+f. 1–25.* 1899.

Lindb.; in this species, according to Andreas, the wall is composed of seven or eight layers and has a thickness of 130 μ. In all these forms he describes local thickenings in the cells of all the layers. In the innermost layers the thickenings are in the form of half rings extending across the inner tangential wall (see TEXT FIG. 10) In the other layers they are in the form of bands on the radial walls. Even here, however, the bands sometimes extend to a greater or less extent along the tangential walls. According to Andreas the structure of the capsule wall in the leafy Hepaticae shows comparatively little variation, and the genus *Herberta* agrees on the whole with his account. It might be added that the valves are covered on the outside by a granular wax-like deposit, and that secondary splits sometimes occur in one or more of the four primary valves.

Many years ago Spruce* described the occurrence of rudimentary shoots on the leaves of *Herberta*. According to his account they arise singly or in pairs from the cells of the vitta in the basal portion of the leaves and never in the divisions. These shoots have not been observed by the writer and are probably developed under exceptional conditions. They represent the only type of vegetative reproduction known in the genus. As Spruce's figures clearly show, the shoots bear three ranks of small bifid leaves and show no signs of dorsiventrality. They resemble in many respects the adventive shoots borne on the leaves of certain species of *Plagiochila*, although they are much less abundantly produced.

REVISION OF THE SPECIES KNOWN FROM EUROPE, CANADA AND THE UNITED STATES

According to most recent writers on the Hepaticae the genus *Herberta* is represented in Europe by only two species. The first of these is *H. adunca* (Dicks.) S. F. Gray, the type of the genus; the second, *H. Sendtneri* (Nees), sometimes known as *H. straminea* (Dumort.) Trevis. The range of *H. adunca*, according to available records, is restricted to Norway, the Faroe Islands and the British Isles; the range of *H. Sendtneri* is even more circumscribed, being accredited only to the Austrian and Bavarian Alps.

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* On the branch-bearing leaves of *Jungermannia juniperina*, Sw. Phytologist 2: 85. 86. 1844. [Illust.]

In thus restricting the range of the latter species, writers differ markedly from Dumortier.* He considered that his *Schisma stramineum*, under which he included *S. Sendtneri* Nees as a synonym, grew in Scotland, as well as in Austria and Germany. His species, in fact, was based on Scottish material. Apparently his only recent follower is Lett,† who admits both *H. adunca* and *H. straminea* as members of the Scottish flora.

Botanists have long recognized the fact, however, that *H. adunca* includes two well-marked forms. These were distinguished by Gottsche,‡ as long ago as 1862, under the names, *α Dicksoniana* and *β Hutchinsiae*. He applied the first name to the plant with shorter, erect-spreading leaves, having straight acuminate divisions, and the second to the plant with longer leaves, hooked when dry and squarrose when moist, having lanceolate, incurved divisions. He considered that *α Dicksoniana* was primarily a plant of Scotland while *β Hutchinsiae* was primarily a plant of Ireland, and yet he made no attempt to restrict the range of either form definitely. Carrington,§ in taking up the name *β Hutchinsiae*, implies that all the Irish specimens are referable to this form and states that the species grows at much lower altitudes in Ireland than in Scotland. He adds that both forms grow in Scotland, the form with ovate or ovate-lanceolate leaves being restricted to higher and exposed mountains. This form is clearly Gottsche's *α Dicksoniana*, although Carrington does not call it by this name. He includes under it Dumortier's *S. stramineum* as a synonym and calls attention to the fact that it approaches *H. Sendtneri*. Although subsequent British writers have paid little attention to Gottsche's names, Schiffner has recently revived them and applied them to specimens in his exsiccatae.||

From a careful study of European specimens referred to *H. adunca*, the writer has reached the conclusion that Gottsche's two so-called forms represent two distinct, but closely related, species. The form *α Dicksoniana*, as its name implies, represents the type of *Jungermannia adunca* Dicks. In the absence of Dickson's original

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* Bull. Soc. Bot. Belgique 13: 125. 1874.

† Hepat. British Isl. 177. 1902.

‡ Rabenhorst, Hep. Eur. *210*. 1862.

§ Trans. Bot. Soc. Edinburgh 7: 454. 1863.

|| Hep. Eur. Exsic. *403-407*. 1912.

material, the statement is supported by Scottish specimens in the Taylor herbarium, received from Hooker, and by the fact that Dickson's plant was collected "in alpibus Scoticis." The type of Dumortier's *Schisma stramineum* was likewise collected "in alpibus Scotiae" and, in the complete absence of all of Dumortier's types, his species may be regarded as a simple synonym of *H. adunca*. The second form, *β Hutchinsiae*, is described below as a new species under the name *H. Hutchinsiae* (Gottsche). In certain respects the true *H. adunca*, as thus restricted, resembles *H. Sendtneri* more strongly than it does *H. Hutchinsiae*. This would account for the fact that Dumortier failed to distinguish between his *Schisma stramineum* and *H. Sendtneri*. The latter species, however, is clearly distinct, and there is no evidence that its range extends beyond the mountains of Austria and Germany.

With regard to the North American specimens which have been referred to *H. adunca*, there has likewise been confusion. There are apparently two species represented, but neither agrees with typical *H. adunca*. The plant from the eastern United States seems to be new and is described below under the name *H. tenuis*; the plant from the Pacific Coast, on the contrary, seems to be referable to *H. Hutchinsiae*. The Alaskan material of this species is unusually satisfactory because it shows androecia, perianths, and sporophytes, all of which are exceedingly rare in European material. The four species considered in the present paper may be distinguished as follows, only vegetative characters being used:

- Leaves mostly 1.2–2 mm. long and 0.45–0.9 mm. wide.
  - Leaves bifid about one half; divisions broad, slightly or not at all curved, acute to acuminate; vitta not distinct, the cells in the divisions mostly 20–40 μ long.
    - Basal portion of leaves normally entire. 1. *H. adunca.*
    - Basal portion of leaves sparingly and coarsely toothed. 2. *H. Sendtneri.*
  - Leaves bifid two thirds to four fifths; divisions narrow, strongly curved, long-acuminate; vitta distinct, the cells in the divisions often 50–70 μ long; basal portion of leaves entire or nearly so. 3. *H. Hutchinsiae.*
- Leaves mostly 0.9–1 mm. long and 0.3–0.35 mm. wide, bifid two thirds to three fourths; divisions narrow, slightly or not at all curved, long-acuminate; vitta distinct, the cells in the divisions often 50–70 μ long; basal portion entire or sparingly and coarsely toothed. 4. *H. tenuis.*

1. HERBERTA ADUNCA (Dicks.) S. F. Gray

Jungermannia adunca Dicks. Plant. Crypt. Brit. 3: 12. *pl. 8, f. 8.* 1793.

Jungermannia juniperina β Hook. Brit. Jung. *pl. 4.* 1812 (in part).

Herberta adunca S. F. Gray, Nat. Arr. Brit. Pl. 1: 705. 1821.

Schisma aduncum Dumort. Comm. Bot. 114. 1822.

Jungermannia juniperina β adunca Lindenb. Nova Acta Acad. Leop.-Carol. 14 (suppl.): 35. 1829 (in part).

Schisma stramineum Dumort. Syll. Jung. 76. 1831; Bull. Soc. Bot. Belgique 13: 125. 1874 (in part).

Schisma juniperinum β Nees, Naturg. Europ. Leberm. 1: 108. 1833.

Sendtnera juniperina β Nees; G. L. & N. Syn. Hep. 239. 1845.

Sendtnera straminea Nees, *l.c.* 240. 1845.

Sendtnera adunca α Dicksoniana Gottsche; Rabenhorst, Hep. Eur. *210* (accompanying text). 1862.

Herberta straminea Trevis. Mem. R. Ist. Lomb. III. 4: 396. 1877 (in part).

Herberta adunca var. *straminea* Cooke, Handb. Brit. Hepat. 70. 1894.

Herberta adunca var. *alpina* Macvicar, Student's Handb. Brit. Hepat. 340. 1912.

Herberta adunca α Dicksoniana Schiffn. Lotos 60: 53. 1912.

Yellowish or brownish green, often tinged with red or purple, sometimes slightly glossy, growing in more or less extensive mats, or scattered among other bryophytes: secondary stems erect or ascending, sparingly and irregularly branched, rigid, mostly 5–10 cm. long but sometimes shorter, about 0.25 mm. (or fourteen cells) wide and 0.18 mm. (or ten cells) thick, the cells everywhere with strongly thickened walls: leaves imbricated, more or less secund, unsymmetrical, ovate, mostly 1.2–1.4 long and 0.45–0.6 mm. wide, bifid about one half, the divisions (in explanate leaves) slightly or not at all curved, acute to acuminate, mostly 0.6–0.7 mm. long and 0.27–0.35 mm. wide at base, margin normally entire; vitta usually indistinct even in the basal region, extending for a short distance into the division but coming to an end considerably below the apex, undivided portion usually 0.2–0.3 mm. long and wide; cells of vitta mostly 35–60 × 22 μ in the basal portion and 20–40 × 20 μ in the divisions, marginal cells in basal portion about 22 μ in diameter, cells between margin and vitta about 24 μ in diameter; thickenings distinct, in the vertical walls mostly 8–10 μ wide; cuticle scarcely striolate: underleaves similar to the leaves but squarrose and symmetrical: male inflorescences borne in an interrupted series in the upper part of a stem; bracts mostly in five or six pairs, similar to the leaves except for the broad basal pocket extending nearly to the sinus, margin normally entire; bracteoles similar to the bracts; antheridia mostly two or three in each axil: female inflorescence not seen. [TEXT FIGS. 14–20.]

The following specimens have been examined:

NORWAY: Drivandefossen Waterfall, Lyster, Bergen Stift, August, 1900, *B. Kaalaas* (listed by Kaalaas in Nyt. Mag. f. Naturv. **40**: 247. 1902; distributed as *H. adunca α Dicksoniana* in Schiffner's Hep. Eur. Exsic. *465*); Söndfjord, Bergen Stift, July, 1903, *E. Jörgensen* (distributed as *H. adunca α Dicksoniana* by Schiffner, *l.c. 464*); Frafjord near Stavanger, July, 1899, *E. Jörgensen* (distributed as *H. adunca α Dicksoniana* by Schiffner, *l.c. 463;* specimens from same locality listed by Kaalaas, *l.c.* **33**: 224. 1893).

FAROE ISLANDS: Syderö, Bordö and Vaagö, May and June, 1896, *C. Jensen* (these are among the specimens listed by Jensen in Bot. Faer. **1**: 127. 1901).

SCOTLAND: Ben Lawers, 1803, *W. J. Hooker* (listed as *Jungermannia juniperina β* by Hooker in Brit. Jung. *pl. 4.* 1812); Craig Chailleach, *G. E. Hunt;* same locality, June, 1900, *S. M. Macvicar;* Camlochan, July, 1843, *W. Gardiner;* Stuichd-an-Lochain, July, 1842, *W. Gardiner;* near summit of Ben More, July, 1897, *H. N. Dixon* (var. *alpina* Macvicar); Glengyle, June, 1895, *Stirling & Kidston;* Ben Vorlich, July, 1901, *S. M. Macvicar* (listed in Ann. Scottish Nat. Hist. 1902: 114); Ben Udlaidh, June, 1903, *S. M. Macvicar*

WALES: Snowden Mountain, June, 1915, *A. H. Graves.*

In Ingham's Census Catalogue of British Hepatics, published in 1913, *H. adunca* is quoted from the following provinces: South Wales, North Wales, Lakes, East Highlands, West Highlands, North Highlands and North Isles. It is quoted also from eleven county divisions in Ireland. It is probable that some of these records, especially those from Ireland, are based on *H. Hutchinsiae.*

Most of the earlier writers not only failed to distinguish *H. Hutchinsiae* from *H. adunca* but considered the combined species a mere variety or form of the Jamaican *H. juniperina* (Sw.) Trevis. (*Jungermannia juniperina* Sw.). Hooker was apparently the first to advance this idea. In the text accompanying *pl. 4* of his British Jungermanniae he recognized *J. juniperina* as a member of the British flora and included *J. adunca* under the variety "*β*," to which he did not even give a definite name. "After a most careful examination of Mr. Dickson's *J. adunca*, compared with others of *J. juniperina*, which I have received from Dr. Swartz," he adds in a critical note, "I am unable to find any characters which can induce me to keep them separate." He then calls attention to the larger size of the Jamaican plant and to the greater readiness with which it regains its original appearance when immersed in water but clearly regards these features of but little moment. Weber* protested against Hooker's treatment of *J. adunca* and maintained it as a valid species, in which he was followed by both S. F. Gray and Dumortier. The majority of contemporaneous writers, however, followed the example of Hooker, and the Synopsis Hepaticarum, in 1845, went so far as to cite Scottish specimens under *Sendtnera juniperina β*, without even mentioning *J. adunca* as a synonym. When Gottsche, nearly twenty years later, distinguished between his *α Dicksoniana* and *β Hutchinsiae*, he pointed out in addition the most marked differences between *H. adunca* and *H. juniperina;* and, since this time, both species have been almost universally recognized.

Among the characters of *H. adunca* which Gottsche emphasized was the lack of teeth on the leaves and underleaves. He pointed out the fact that young leaves sometimes showed five to eight primordial papillae at the base, these structures representing the rudiments of teeth, but of actual teeth he found no development. Although this description will apply to the vast majority of leaves, it will not apply to all. An occasional leaf will show one or perhaps two teeth in the basal region. Such a tooth usually consists of a single cell, serving as a stalk for a papilla, but it sometimes attains a length of several cells and becomes more lobe-like in appearance. The occurrence of these teeth, in view of their infrequency and irregularity, is doubtless more or less abnormal. The same thing may be said of the trifid leaves and of the blunt divisions which occasionally come to light, when a large series of leaves is examined.

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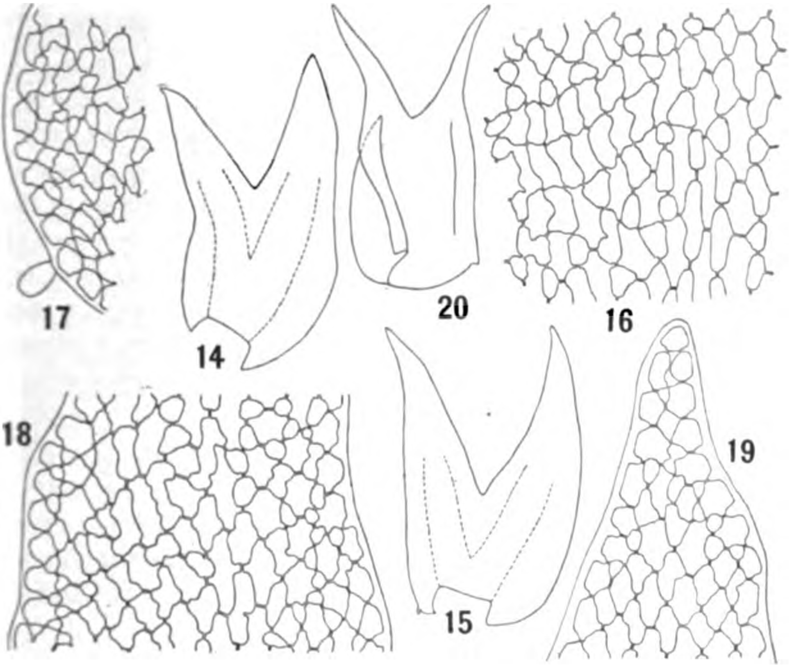
* Hist. Musc. Hepat. Prodr. 54. 1815.

Although Dickson's original figures show perianths and mature capsules, these organs seem to be very rarely produced.



FIGS. 14–20. HERBERTA ADUNCA (Dicks.) S. F. Gray

14, 15. Leaves, × 40. 16. Cells from the basal portion of a leaf, showing the basal vitta on the right, × 225. 17. Dorsal base of a leaf, × 225. 18. Cells from the upper part of a dorsal leaf-division, × 225. 19. Cells from the apex of the same division, × 225. 20. Perigonial bract, × 40. FIGS. 14, 16–19 were drawn from Norwegian specimens collected by E. Jörgensen and distributed in Schiffner's Hep. Europ. Exsic. *464*; FIGS. 15, 20, from Norwegian specimens collected by B. Kaalaas and distributed in the same exsiccatae *465*.

Hooker stated definitely that the only fruiting plants he had seen were Scotch specimens furnished by Dickson. Pearson* did not know fruiting plants at all; his description and figures of the bracts and perianths were drawn from Cuban specimens referred to *H. juniperina*, his idea being that the reproductive parts in this species would not differ appreciably from those of *H. adunca*. Perianths were likewise unknown to Stephani, although he quotes from Kaalaas a brief description of bracts, perianths and capsule. Whether Kaalaas actually saw these structures in *H. adunca* is, however, doubtful. The description quoted by Stephani was taken (with certain arbitrary changes) from the account of the *genus* given by Kaalaas,* the account of the species merely stating that the reproductive organs were "ut in genere." According to Macvicar female plants are frequent, but perianths are unknown in the British Isles. He quotes Hooker's statement about Dickson's fruiting plants but suggests that there was probably some mistake on Dickson's part. If this idea could be substantiated there would be no evidence left that *H. adunca* had ever been found in fruit. It is to be hoped that further explorations may be rewarded by the discovery of the missing parts, although a persistent sterility would not be surprising in the present genus, where other well-marked species apparently produce neither archegonia nor antheridia.

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* Hep. British Isles 100, 101. *pl.* 36, *f.* *11*, *12*. 1900.

2. **Herberta Sendtneri** (Nees) comb. nov.

Schisma Sendtneri Nees, Naturg. europ. Leberm. **3**: 575. 1838.
Jungermannia Sauteriana Hüben. & Genth, Deutschl. Leberm. *108*. 1839 (*nomen nudum*); G. L. & N. Syn. Hep. 240. 1845 (as synonym).
Sendtnera Sauteriana Nees; G. L. & N. Syn. Hep. 240. 1845.
Schisma stramineum Dumort. Bull. Soc. Bot. Belgique **13**: 123. 1874 (in part). Not 1831.
Herberta straminea Trevis. Mem. R. Ist. Lomb. III. **4**: 396. 1877 (in part).

Brownish green, not glossy, growing in more or less extended mats: secondary stems erect or ascending, sparingly and irregularly branched, rigid, mostly 5–8 cm. long, about 0.35 mm. (or fifteen cells) wide and 0.3 mm. (or twelve cells) thick, the cells everywhere with strongly thickened walls: leaves imbricated, more or less secund, broadly ovate, mostly 1.2–1.6 mm. long and 0.75–1.1 mm. wide, bifid one half or a little more, the divisions (in explanate leaves), slightly or not at all curved, acute to acuminate, mostly 0.6–0.9 mm. long and 0.4–0.55 mm. wide, margin irregularly toothed near the base, the teeth mostly two to five on each side, sometimes small, sometimes larger and lobe-like; vitta indistinct even in the basal region, extending into the divisions but soon coming to an end, undivided portion about 0.25 mm. long and 0.35 mm. wide; cells of vitta mostly 40–70 × 18 μ in the basal portion and 30–40 × 16 μ in the divisions, marginal cells in the basal portion about 14 μ in diameter, cells between margin and vitta about 16 μ in diameter; thickenings distinct in the vertical walls, mostly 4–6 μ wide; cuticle distinctly striolate-verruculose, especially near the base: underleaves similar to the leaves but shorter and more symmetrical: inflorescence unknown.

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* Nyt Mag. f. Naturv. **33**: 223. 1893.

The following specimens have been examined:

AUSTRIA (TIROL): Kleiner Rettenstein near Jochberg, *A. Sauter* (distributed as *Sendtnera Sauteriana* in Rabenhorst's Hep. Europ. *33a*); near Kitzbühel, August, 1882, *J. Breidler*; Rosskogl, *F. Arnold* (distributed as *Sendtnera Sauteriana* in Gottsche & Rabenhorst's Hep. Europ. *422*); Sellraintal, August, 1912, *H. von Handel-Mazzetti* (distributed as *H. straminea* in Schiffner's Hep. Europ. Exsic. *468*).

Müller and other writers cite the species from Bavaria and Salzburg, as well as from Tirol.

The present species bears a strong resemblance to the true *H. adunca* and it is not at all surprising that botanists have sometimes had difficulty in distinguishing them. Both normally grow in broad mats, their color is much the same except for the fact that *H. Sendtneri* seems never to be tinged with red or purple, their leaves are equally imbricated and divided to about the same extent, their divisions are less curved than in most species of the genus, and the vitta is poorly defined in both, the branches coming to an end far below the apices of the leaves. At the same time they exhibit excellent differential characters. The leaves in *H. Sendtneri* are relatively broader than in *H. adunca*, the same thing is true of the leaf-divisions, and the thickenings in the leaf cells are less conspicuous, those in the vertical walls being only about half as wide. The most striking differences between the two species, however, are to be found in the basal teeth. In *H. adunca*, as already noted, basal teeth are either absent altogether or else occur as a rare abnormality. In *H. Sendtneri* they form a conspicuous feature of the species. It is true that they may not be present on every individual leaf. Nevertheless, if a series of leaves is examined, the majority will show the basal teeth clearly. Some of the teeth consist of single cells, but most of them are three to ten cells long and often two to four cells wide at the base. Occasionally an even larger, lobe-like tooth is present. Although the basal teeth are almost always marginal it is sometimes possible to demonstrate a surface tooth.

3. **Herberta Hutchinsiae** (Gottsche) sp. nov.

Jungermannia juniperina β Hook. Brit. Jung. *pl. 4*. 1812 (in part).

Sendtnera adunca β Hutchinsiae Gottsche; Rabenhorst, Hep. Eur. *210* (accompanying text). 1862.

Herberta adunca β Hutchinsiae Schiffn. Lotos **60**: 54. 1912.

Yellowish or brownish green, sometimes tinged with red or purple, often somewhat glossy, growing in more or less extensive mats or in pendent tufts, sometimes mixed with other bryophytes: secondary stems erect, ascending or pendulous, rigid, mostly 5–10 cm. long but sometimes shorter, about 0.25 mm. (or fourteen cells) wide and 0.2 mm. (or twelve cells) thick, the cells everywhere with thickened walls, although showing a fairly marked difference between cortical and median regions: leaves imbricated, strongly secund, unsymmetrical, narrowly ovate, mostly 1.2–1.5 mm. long and 0.45–0.5 mm. wide, the divisions strongly curved and more or less divergent, acuminate to long-acuminate, mostly 0.8–1.2 mm. long and 0.2–0.25 mm. wide; margin normally entire; vitta distinct, extending far out into the divisions but hardly to the apices, undivided portion mostly 0.15–0.18 mm. long and 0.25–0.3 mm. wide; cells of vitta mostly 30–75 × 14–18 μ in the basal portion and 25–50 × 18–20 μ in the divisions, marginal cells in the basal region mostly 16–20 μ in diameter, cells between margin and vitta mostly 18–24 μ in diameter; thickenings distinct, in the vertical walls about 6 μ wide; cuticle faintly but distinctly striolate-verruculose: underleaves similar to the leaves but symmetrical, squarrose, and with straight divisions: male inflorescences normally borne in an interrupted series in the upper part of a stem, more rarely on a lateral or ventral branch; bracts and bracteoles mostly in four to six series, similar to the leaves but with straighter and less divergent divisions and a broad basal pocket, about 1 mm. long and 0.45 mm. wide, margin subentire to sparingly and irregularly denticulate; antheridia mostly two or three in each axil: female inflorescence apparently always terminal on a stem, often with one or more subfloral innovations; bracts and bracteoles similar, in about three series, those of the innermost series mostly 2.5–3.5 mm. long and 0.7–0.9 mm. wide, suberect and appressed to the perianth, bifid a little more than one half with slender, acuminate, subparallel divisions, margin copiously and shortly denticulate or dentate to or just above the level of the sinus, otherwise entire; bracts and bracteole of the other series a little shorter and often squarrose, the divisions usually more or less divergent, the margin varying from denticulate to coarsely and irregularly dentate; paraphyllia occasionally present, small and irregular; perianth ovate, not contracted at the mouth, about 3.5 mm. long and 0.8 mm. wide, divided for about half the length into six lanceolate, long-acuminate divisions, papillae numerous along the margins of the divisions near the base and on the inner surface of the perianth, usually sessile but sometimes borne on very short stalks: capsule brown, oval, about 1 mm. in diameter, splitting usually into six to eight valves; spores brown, about 25 μ in diameter, minutely echinulate; elaters brown, usually with two loose spirals, rarely with three, about 10 μ wide. [PLATE 8.]

The following specimens have been examined:

NORWAY: Lyse near Stavanger, July, 1897, *E. Jörgensen* (distributed as *H. adunca β Hutchinsiae* in Schiffner's Hep. Eur. Exsic. *466;* specimens from the same locality listed by Kaalaas, as *H. adunca*, in Nyt. Mag. f. Naturv. **40**: 247. 1902).

SCOTLAND: Moidart, Inverness, 1898, 1899 and 1901, *S. M. Macvicar* (listed as *H. adunca* in Jour. Bot. 37: [3]. 1899; specimens from same region distributed as *H. adunca β Hutchinsiae* in Schiffner's Hep. Europ. Exsic. *467*); without definite locality or date, specimen from Hooker herbarium; Ben Vorlich, July, 1901, *S. M. Macvicar;* Ben Lavigh, July, 1901, *R. H. Meldrum.*

ENGLAND: Borrowdale, Cumberland, July, 1844, *Mr. Brown;* April, 1893, *W. H. Pearson.*

WALES: Craig-y-can, Merioneth, May, 1877, *C. J. Wild & W. H. Pearson* (distributed as *H. adunca* in Carrington & Pearson's Hep. Brit. Exsic. *42*).

IRELAND: Bantry, *Miss Hutchins;* Killarney, *B. Carrington* (distributed as *Sendtnera adunca β Hutchinsiae* in Rabenhorst's Hep. Europ. *210*); Brandon Mountain, *D. Moore* (distributed as "*Sendtnera juniperina* Nees = *Sendtnera adunca* Dickson" in Gottsche & Rabenhorst's Hep. Europ. *491*); same locality, no date, *W. Mitten*, several specimens; same locality, 1881, *D. Mc-*

Ardle; Mangerton Mountain, no date, *W. Mitten;* Mt. Cromaglown, *R. Spruce;* without definite locality or date, specimen from the Hooker herbarium.

ALASKA: Sitka, collector and date unknown (specimen received from Lindberg, in the Austin herbarium); Yes Bay, August, 1895, *T. Howell 1810* (listed as *H. adunca* by the writer in Proc. Wash. Acad. Sci. **2**: 309. 1900); Hot Spring, Baranof Island, June, 1899, *W. Trelease 1525a, 1808* (Harriman Expedition, listed as *H. adunca* by the writer, *l.c.*); Metlakatla, May, 1913, *R. B. Wylie 76, 97; T. C. Frye 109* in part; Ratz Harbor, June, 1913, *T. C. Frye 309;* Saltery Cove, June, 1913, *T. C. Frye 320;* Nichols Bay, June, 1913, *T. C. Frye 384;* Morse Cove, June, 1913, *T. C. Frye 446;* Brownson Bay, June, 1913, *T. C. Frye 470; A. S. Foster 517;* Augustine Bay, July, 1913, *T. C. Frye 561; A. S. Foster 677;* Port San Antonio, July, 1913, *T. C. Frye 605, 649;* Aats Bay, July, 1913, *T. C. Frye 925.* The specimens of Frye, Foster, and Wylie were collected under the auspices of the Kelp Investigation Expedition of the United States Bureau of Soils. They have already been listed by the writer, as *H. adunca,* in Bull. Torrey Club **41**: 601. 1915.

BRITISH COLUMBIA: Fraser Reach, Princess Royal Island, June, 1899, *F. V. Coville & T. H. Kearney* (Harriman Expedition, probably the basis for Osgood's record of *H. adunca* in U. S. Dept. Agric. Biol. Surv. Bull. 21: 14. 1901); Port Renfrew, August, 1902, *S. A. Skinner* (listed as *H. adunca* by the writer in Postelsia 1906: 228); Ucluelet, 1909, *J. Macoun 2* (specimens from same locality distributed as *H. adunca* by Miss Haynes in Amer. Hepat. *72* and by Macoun in Can. Liverworts *83*); Swanson Bay, May, 1913, *T. C. Frye 1174* (Kelp Expedition).

The specimens collected by Miss Hutchins at Bantry, Ireland, and now preserved in the Mitten herbarium at the New York Botanical Garden, should be considered the type of the species.

The following records for *H. adunca* from Alaska should also be noted: without definite locality, date or collector's name (listed by Underwood in Zoe **1**: 366. 1891); St. Paul Island, Pribolof Islands, *C. H. Merriam* (listed by Merriam in Proc. Biol. Soc. Washington **7**: 150. 1892). Underwood's record was probably based on Lindberg's specimens cited above. Merriam's record, however, was based on specimens in the United States National Herbarium, which, in the writer's opinion, represent a slender form of *Anthelia julacea* (L.) Dumort. This species is now known from several localities in Alaska, and additional specimens, essentially like those of Merriam, were collected on St. Paul Island, in 1897, by T. C. Kincaid (*49*).

The narrower and more deeply divided leaves of *H. Hutchinsiae*, with their more slender and strongly curved divisions will usually distinguish the species from *H. adunca* at a glance. In doubtful cases the distinct vitta extending far out into the divisions will decide the determination. The more gradual tapering of the divisions is clearly brought out by counting their width in cells. In *H. Hutchinsiae*, if the counts are made at a distance of 0.2 mm. from the apices, the divisions are found to have a width of from two to four cells; in *H. adunca* the corresponding counts will usually give from five to eight cells. Counts at the bases of the divisions are much less conclusive, on account of the fact that the divisions in *H. Hutchinsiae* are relatively longer, the bases thereby being often as wide as in *H. adunca*.

Among the specimens listed above, those from Norway are somewhat aberrant. Although some of the shoots conform closely to the type, others bear leaves which are considerably larger. One of the largest leaves measured had a length of 2.4 mm. and a width of 0.95 mm.; another, a length of 2 mm. and a width of 1 mm. The dorsal divisions of these measured, respectively, 1.2 × 0.45 mm. and 1.05 × 0.4 mm. Since these leaves are relatively broader than is usual, it might appear at first sight as if the large-leaved shoots approached *H. adunca*, but the distinct vittae present would seem to preclude this idea. In all probability they represent shoots developed under unusual conditions, perhaps exceptionally favorable from a nutritive standpoint; the large leaves might then be regarded as abnormal.

The androecia in *H. Hutchinsiae* are not absolutely constant in position. In normal cases they are borne on the secondary stems just as in *H. adunca*. Under these circumstances an androecium usually proliferates at the apex and then produces a new androecium after a short series of vegetative leaves. In several instances, however, androecia on ventral or lateral branches have been observed. These are apparently never produced unless the growth of the main male axis is brought to an end in some way, possibly through the failure of an androecium to proliferate, possibly through an accident of some sort. In either case a branch tends to take the place of the main axis and to assume its functions, precisely as a ventral branch of a sterile axis or a subfloral innovation would do. When, therefore, an androecium is borne on a branch of this character, its position can not be regarded as typical.

These considerations gain in significance when *H. Hutchinsiae* is compared with *H. dicrana* (Tayl.) Trevis., a closely related species of the Himalayas. The writer's knowledge of this species is largely based on specimens received from Levier and collected by Decoly and Schaul (*782*) near Kurseong in Sikkim-Himalaya, in May, 1899. These specimens contain both male and female plants and are of especial interest because they served as the basis for Schiffner's statements regarding the androecia of *H. dicrana*.* He notes their occurrence on the ends of branches, their small size, the small number of bracts (about four pairs) which they bear, and the fact that they are sterile at the apices. The branches which bear the androecia are ventral and vary greatly in length. Sometimes the development of the antheridia brings the growth of the branch to an end, but a sterile proliferation of the androecium often occurs. The formation of the male branches seems to be a perfectly normal process and is not preceded by a cessation of growth of the main stem as in *H. Hutchinsiae*. It follows, therefore, that what occurs abnormally in the northern species has become normal in the Himalayan species. It should be noted, however, that ventral androecia are not absolutely constant even in *H. dicrana*. One example was observed where the androecium was borne on a main stem; it had somewhat larger bracts and bracteoles than the ventral androecia but resembled them in other respects. Aside from the difference in the position of the androecia, *H. dicrana* resembles *H. Hutchinsiae* very closely. The leaves and underleaves, the bracts and bracteoles, and the perianths are much the same in the two species, although the divisions of the leaves in *H. dicrana* usually are less strongly curved. The latter species, moreover, is slightly larger, the leaves are less crowded and the thickening of the cell-walls is less pronounced.

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* Hedwigia 50: 148. 1910.

4. **Herberta tenuis** sp. nov.

Schisma juniperinum Sulliv. Musc. Alleg. *258*. 1846. Not Dumort.

Sendtnera juniperina Sulliv.; A. Gray, Man. 689. 1848. Not Nees.

Herberta adunca Underw. Bot. Gaz. **14**: 195. 1889. Not S. F. Gray.

Yellowish or brownish green, rarely tinged with red, growing in more or less extensive mats: secondary stems erect or ascending, sparingly and irregularly branched, rigid, mostly 2–4 cm. long, about 0.15 mm. (or ten cells) wide and 0.13 mm. (or nine cells) thick, outer layer of cells with strongly thickened walls, interior cells with slightly thickened walls: leaves scattered to loosely imbricated, subsquarrose to slightly secund, a little unsymmetrical, subovate, mostly 0.9–1 mm. long and 0.3–0.35 mm. wide, bifid two thirds to three fourths, divisions (in explanate leaves), divergent, slightly or not at all curved, long-acuminate, mostly 0.6–0.7 mm. long and 0.15–0.18 mm. wide, margin entire or with an occasional basal tooth; vitta distinct, extending far out into the divisions but not to the apices, undivided portion about 0.1 mm. long and 1.5 mm. wide; cells of vitta mostly 20–55 × 14 μ in the basal portion and 20–35 × 14 μ in the divisions, marginal cells in the basal region about 14 μ in diameter, in the divisions about 17 μ, cells between margin and vitta about 20 μ; thickenings distinct but not so strongly developed as in most species, in the vertical walls mostly 3–4 μ wide; cuticle minutely striolate-verruculose: underleaves similar to the leaves but symmetrical; inflorescence unknown. [TEXT FIGS. 21–29.]

The following specimens have been examined:

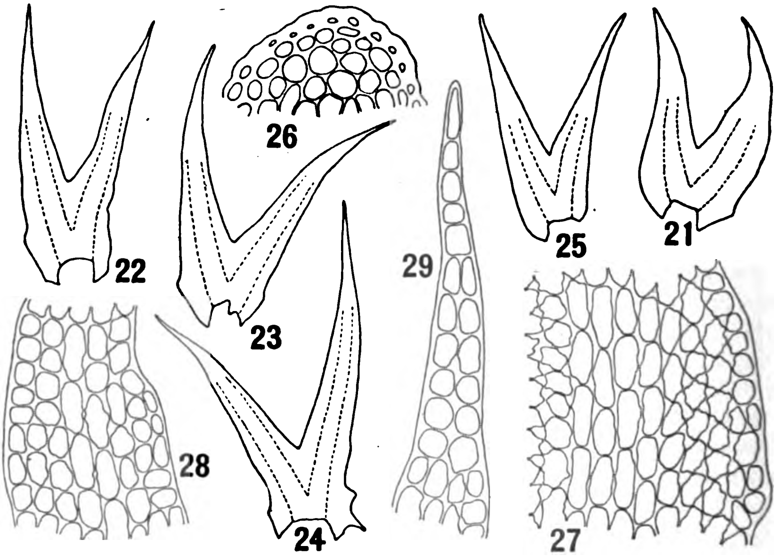
NEW YORK: Kaaterskill Falls, Catskill Mountains, *C. H. Peck* (listed by Peck, as *Sendtnera juniperina*, in Rep. New York State Mus. Nat. Hist. **19**: 70. 1866; both "Cauterskill" Falls and High Peak, Catskill Mountains, are mentioned here); Austin's Hep. Bor.-Amer. *82*, distributed as *Sendtnera juniperina*, is also *H. tenuis* and may possibly include some of Peck's material, the label reading: "Catskill Mountains, New York, *Peck*, Greenwood Mts., N. J., *Aust.;* also in the Alleghanies southward."

NEW JERSEY: Greenwood Mountains, Passaic County, November, 1866, *C. F. Austin* (listed by Britton, as *H. adunca*, in Cat. Pl. New Jersey 351. 1889); Austin's Hep. Bor.-Amer. *82* (see above) is probably made up largely of material from this locality.

PENNSYLVANIA: Stony Creek, Somerset County, *F. Wolle.*

VIRGINIA: summit of White Top Mountain, Washington County, May, 1892, *A. M. Vail & E. G. Britton 9, 91*, and numerous unnumbered specimens; same locality and date, *J. K. Small 77, 79* (listed by Small & Vail, as *H. adunca*, in Mem. Torrey Club **4**: 193. 1894).

WEST VIRGINIA: Tibbs Run, Monongalia County, September, 1892, *C. F. Millspaugh 1659* (listed by Millspaugh, as *H. adunca*, in Prelim. Cat. Fl. W. Va. 496. 1892); Quarry Run, Monongalia County, 1903, *A. LeR. Andrews.*



FIGS. 21–29. HERBERTA TENUIS Evans

21–25. Leaves, × 40. 26. Transverse section of a mature stem, × 225. 27. Cells from the lower part of a leaf, including the vitta just above the forking. × 225. 28. Cells from the upper part of a dorsal leaf-division, × 225. 29. Cells from the apex of a division, × 225. FIG. 21 was drawn from specimens distributed in Austin's Hep. Bor.-Amer. *82*; the remaining figures, from the type specimen.

NORTH CAROLINA: "in montibus Carolinae," *F. Michaux* (listed by Michaux, as *Jungermannia sertularoides*, in Fl. Bor. Amer. **2**: 278. 1803), the label reading as follows: "Junga sertularoides Rich. Fl. b. Am. a Jung. trichophylla vox aut non distincta! Hb. Hooker"; "in montosis editissimis Carolinarum," 1843, *A. Gray & W. S. Sullivant* (distributed, as *Schisma juniperinum*, in Sullivant's Musc. Alleg. *258*, and listed by Sullivant, as *Sendtnera juniperina*, in A. Gray, Man. 689. 1848); top of Black Mountain, June, 1850, *L. Lesquereux;* Grandfather Mountain, August, 1891, *J. K. Small 32* (also distributed, as *H. adunca*, in Underwood & Cook's Hep. Amer. *126*); Grandfather Mountain, September, 1901, *G. F. Atkinson 11420, 11501* (listed by Andrews, as *H. adunca*, in Bryologist **17**: 59. 1914); near Shulls Mills, Blue Ridge Mountains, September, 1901, *G. F. Atkinson 12054* (listed by Andrews, *l.c.*).

Dr. Small's specimen from North Carolina, No. 32, may be designated the type.

Two additional records for *H. adunca* from the eastern United States may likewise be noted, namely: Carbon County, Pennsylvania, *E. A. Rau* (listed by Porter in Cat. Bryoph. & Pteridoph. Pennsylvania 9. 1904), and mountains of western North Carolina, 1907, *A. J. Grout* (listed by Grout in Bryologist **12**: 54. 1909). In all probability these records were based on *H. tenuis*.

The present species is closely related to *H. Hutchinsiae* but is considerably smaller. Although at first sight the small size might appear to be due to poor development, the study of a large series of specimens from many localities shows pretty conclusively that this is not the case. The size is of course subject to more or less variation, as in all species of *Herberta*, but the measurements of the leaves given in the description represent a fair average of the more robust plants studied, and are only about two thirds as great as the corresponding measurements in *H. Hutchinsiae*. The difference in size is brought out with especial clearness by counting the width of the basal portion in cells between the vitta and the margin. In *H. Hutchinsiae* such a count would give from five to seven cells; in *H. tenuis* from three to five cells. Aside from the difference in size the slightly curved or straight divisions in *H. tenuis* and the thinner cell-walls will distinguish the species from *H. Hutchinsiae*, where the divisions are normally strongly curved and the thickening of the cell-walls much more distinctly marked.

The basal teeth in *H. tenuis*, although an inconstant feature, deserve a few words of comment. When they occur there may be one, or, rarely, two teeth on each side, and the underleaves tend to produce them more frequently than the side-leaves. The teeth are of fair size, often involving several cells, and may be rounded or sharp. In the latter case they are especially conspicuous (TEXT FIG. 24). It has already been noted that teeth form an important feature of the leaves in *H. Sendtneri,* whereas in *H. adunca* and *H. Hutchinsiae* the margin is normally entire. *H. tenuis* occupies an intermediate position in this respect, the teeth being less frequent than in *H. Sendtneri* but more frequent than in either of the other species.

The present paper is based largely on material in the herbarium of Yale University. This has been supplemented by specimens from the Taylor herbarium at Harvard University and from the herbarium of the New York Botanical Garden. Additional specimens have been received from Professsr A. LeRoy Andrews of Cornell University, from Mr. S. M. Macvicar of Invermoidart, Scotland, and from Mr. C. Jensen of Hvalsö, Denmark. The writer would express his sincere thanks to all who have aided him in his work.

SHEFFIELD SCIENTIFIC SCHOOL,
YALE UNIVERSITY.

Explanation of plate 8

HERBERTA HUTCHINSIAE (Gottsche) Evans

FIGS. 1–3. Leaves, × 40.

FIG. 4. Cells from the lower part of a leaf, showing the basal vitta, × 225.

FIG. 5. Cells from the dorsal base of a leaf, showing two rudimentary teeth, × 225.

FIG. 6. Cells from the upper part of a dorsal leaf-division, × 225.

FIG. 7. Cells from the apex of the same division, × 225.

FIGS. 8, 9. Perigonial bracts, × 40.

FIG. 10. Perichaetial bract from next to the last pair, × 27.

FIG. 11. Perichaetial bract from the innermost pair of the same involucre, × 27.

FIG. 12. Paraphyllium from the same involucre, × 27.

Fig. 13. Perianth, spread out flat, × 27.

FIG. 14. Transverse section of perianth, × 40.

FIG. 1 was drawn from Irish specimens collected by B. Carrington and distributed in Rabenhorst's Hep. Europ. *210*; FIG. 2, from Scottish specimens collected by S. M. Macvicar and distributed in Schiffner's Hep. Europ. Exsic. *467*; the remaining figures, from specimens collected by T. C. Frye at Port Antonio, Alaska, *649*.

INDEX TO AMERICAN BOTANICAL LITERATURE

1911-1917

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the word America being used in the broadest sense.

Reviews, and papers that relate exclusively to forestry, agriculture, horticulture, manufactured products of vegetable origin, or laboratory methods are not included, and no attempt is made to index the literature of bacteriology. An occasional exception is made in favor of some paper appearing in an American periodical which is devoted wholly to botany. Reprints are not mentioned unless they differ from the original in some important particular. If users of the Index will call the attention of the editor to errors or omissions, their kindness will be appreciated.

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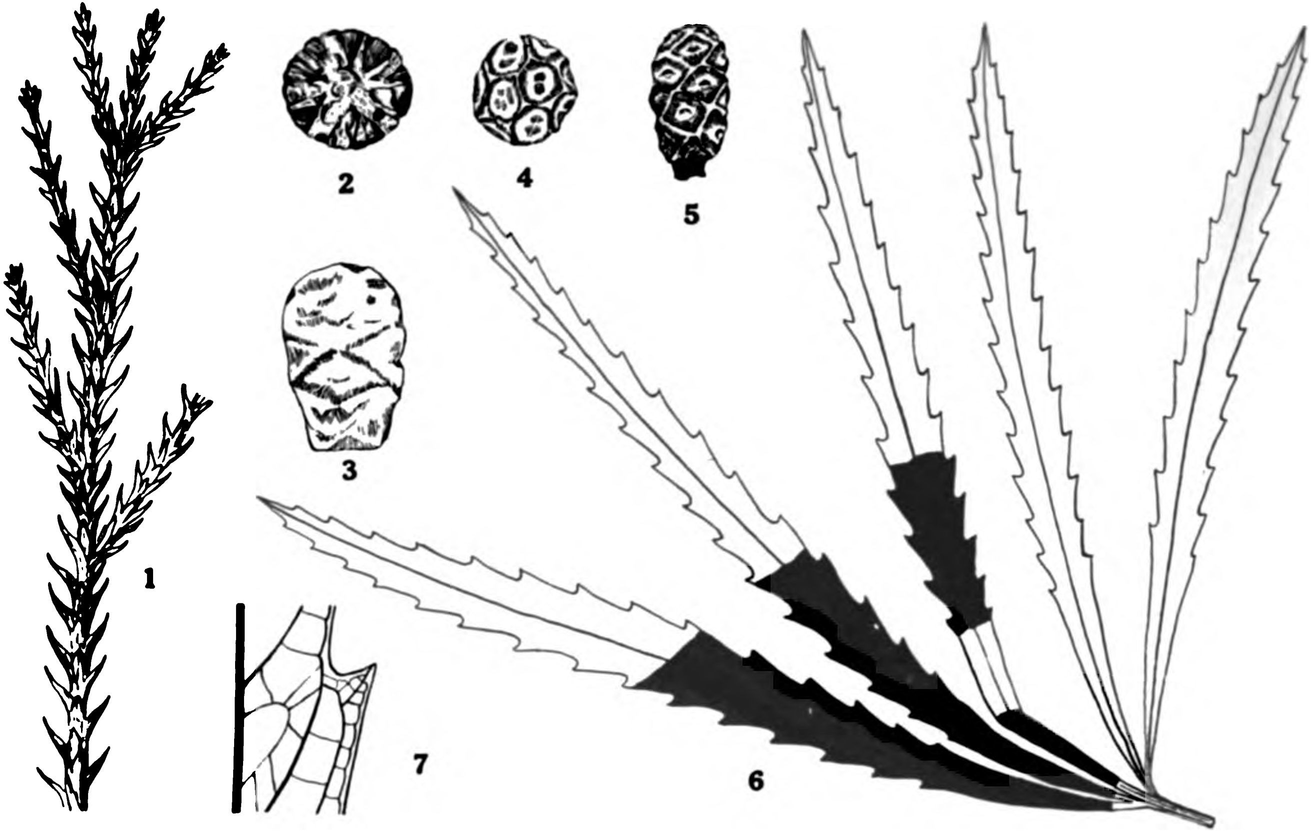
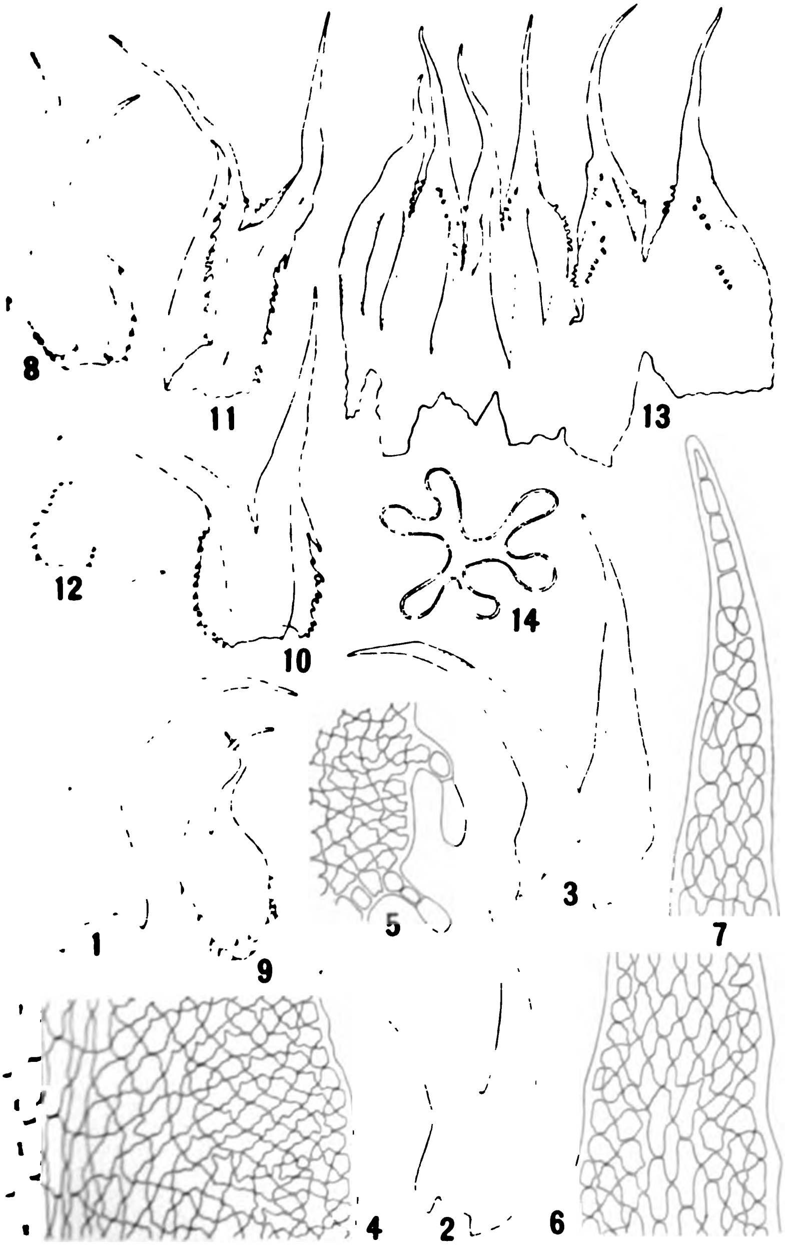


1–5. SEQUOIA CONCINNA Heer
6, 7. DEWALQUEA INSIGNIFORMIS Berry



HERBERTA HUTCHINSIAE (Gottsche) Evans

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BULLETIN

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TORREY BOTANICAL CLUB

Notes on Hawaiian Lobelioideae, with descriptions of new species and varieties

JOSEPH F. ROCK

(WITH PLATES 9–16)

The writer has prepared a monograph on the Hawaiian lobelioideous genera *Cyanea*, *Rollandia*, *Clermontia*, *Delissea*, *Trematolobelia* and *Brighamia*, and on the endemic species of the genus *Lobelia*. But owing to the length of time necessary for the publication of the rather voluminous manuscript of the whole monograph, he thought it wise to publish the new species first in botanical periodicals or bulletins. The majority of the new species of *Cyanea* and *Clermontia* have appeared in the writer's book on the Indigenous Trees of the Hawaiian Islands (1913), in Botanical Bulletin No. 2, of the College of Hawaii Publications and in the Bulletin of the Torrey Botanical Club. With two exceptions the species and varieties described in the present paper belong to the genus *Cyanea*, which has by far the largest number of species of the lobelioideous genera represented in the Islands. *Clermontia* comes next, with *Rollandia* and *Delissea* following.

1. **Cyanea noli-me-tangere** sp. nov.

Plant subherbaceous, 3–20 dm. high, terrestrial, branching only when broken, spinescent throughout, with the exception of the fruit and corolla; stem green, somewhat fleshy, entirely covered with strong, pale yellow, hollow spines; leaves bright green, ovate-oblong, somewhat acute at the apex, rounded at the base, thin in texture, irregularly and sinuately notched, with minute, mucronulate teeth along the margin, covered with yellow spines at more or less regular intervals of 7–10 mm. on both

[The Bulletin for April (44: 167–228. *pl.* 7, 8) was issued April 16, 1817.]

surfaces, 9–21 cm. long, 4–7.5 cm. wide, on spinescent petioles 1.5–4 cm. in length, glabrous or slightly pubescent; inflorescence axillary, the spinescent peduncle 2–2.5 cm. long, multibracteate two thirds its length; pedicels 6–10 mm. long when in flower, 20 mm. when in fruit, pubescent with whitish hairlets; calyx similarly pubescent, calycine lobes triangular, acuminate, 3 mm. long; corolla greenish white, slightly pubescent, strongly curved, 4 cm. long, of unequal width, broadest portion (7 mm.) beyond the dorsal slit, the latter extending one third the length of the corolla, upper corolla lobes 12 mm. long, the three lower 8 mm. long; staminal column green, glabrous, as are the anthers, only the two lower being penicillate; stigma pubescent; fruit orange-colored, pubescent, ovoid, 1 cm. long; seeds dark brown, shining. [PLATE 9.]

HAWAII: terrestrial, in the forests of Glenwood, usually in the more or less uniform fern forest at an elevation of 3,500 feet, March 20, 1908, *H. L. Lyon 8847* (fruiting specimens); December 23, 1914, *J. F. Rock & M. L. Copeland 10351* (flowering specimens), type. Both specimens are in the herbarium of the College of Hawaii.

MAUI: in the rain forest on the northwestern slopes of Mt. Heleakala, along the Honomanu trail, April, 1911, *J. F. Rock 8796a* (leaf specimens only); in the forests back of Nahiku, at an elevation of 4,000 feet, April, 1911, *J. F. Rock.*

In Hillebrand's herbarium in the Botanical Museum at Berlin there are four specimens of a *Cyanea* which he labeled with a manuscript name. Three of these came from Molokai and one from Maui. Two of the specimens, which are undoubtedly related to the writer's *C. noli-me-tangere,* belong to *Cyanea scabra* Hillbrd., while the others represent two varieties, probably of the latter.

Cyanea noli-me-tangere differs from *Cyanea scabra* in the spinescent leaves and in the corolla lobes which are smooth instead of scabrous. The corolla lobes of Hillebrand's plants are also scabrous. *Cyanea noli-me-tangere* is related to *Cyanea palakea* Forbes. It differs from it in the longer-petioled, spinescent leaves, which are ovate to obovate-oblong and not sinuate. *Cyanea palakea* Forbes seems to be very close to the writer's *Cyanea stictophylla* from near the locality where Forbes collected his specimens.

2. **Cyanea Copelandii** sp. nov.

Plant herbaceous, epiphytic, 30–40 cm. tall, not branching, stem fleshy throughout, green, with distant leaf scars; leaves dark green, oblong, acuminate at the apex, gradually narrowing and slightly rounded below, 22.5–27 cm. long, 5–8 cm. wide, on petioles 4.5 5.5 cm. long, midrib prominent underneath as are the veins, the latter slightly impressed above, margin of leaf unevenly wavy, minutely and closely denticulate, denticulation mucronulate, glabrate above, slightly pubescent below, especially the veins and midrib, pubescence consisting of minute reddish brown hairlets; inflorescence axillary, peduncles 4–5 cm. long when in flower, 5.5 cm. long when in fruit, with a rusty colored pubescence; pedicels three or four, 11–16 mm. long, 2 mm. thick, calyx greenish with purplish tinge, pubescent, ovarian portion ovoid-oblong, 1 cm. high, 6 mm. in diameter, ten-ribbed, the calycine lobes triangular-dentiform, the tips dark purplish, 2 mm. long; corolla yellowish flesh-colored, slightly curved when open, of equal width throughout, 4 cm. long, 6 mm. wide, the dorsal slit extending not quite to the middle, the two upper lobes 2 cm. long, the three lower 1 cm. long, with a purplish pubescence mainly along the nerves, the tips of the lobes mucronulate; staminal column green, pale, perfectly glabrous, shorter than the corolla, the tube glabrous inside, with the exception of the base which is tufted with whitish hairlets; style green, glabrous, stigma slightly two-lobed; anthers glabrous, the lower only penicillate; fruit dark orange, oblong, 15 mm. long, 10 mm. wide, slightly ribbed, crowned by the calycine teeth. [PLATE 10.]

HAWAII: on trunks of trees and tree ferns, not common, in the rain forest of Glenwood, at an elevation of 3,500 feet, December 23, 1914, *J. F. Rock & M. L. Copeland 10350* (flowering and fruiting specimens), type, in the herbarium of the College of Hawaii.

Named for my friend, Mr. M. L. Copeland, who accompanied me on botanical excursions on Hawaii. The species belongs to the herbaceous cyaneas and is related to *Cyanea stictophylla* Rock and *Cyanea communis* Rock.

3. **Cyanea Fernaldii** sp. nov.

Leaves lanceolate-oblong, thin in texture when dry (chartaceous), dark green above, paler underneath, with prominent midrib, subentire with somewhat wavy margin, minutely and closely denticulate, bluntly acuminate at the apex, 34–40 cm. long, puberulous on both sides, the apparently fleshy petiole 12 cm. or more in length, near the blade of the leaf showing signs of murication; peduncle fleshy (apparently), nearly as long as the petioles, 8–10 cm. long or a little more, naked its entire length, pubescent with round scars near the apex; bracts foliaceous, 3.5 cm. long, dentate, only present at the apex of peduncle; pedicels short, filiform, 12–15 mm. long, pubescent; calycine lobes triangular, 2.5 mm. long, the ovarian portion of calyx 7 mm. long, oblong, nearly cylindrical, pubescent; corolla evidently white, pubescent outside, slightly curved, 4 cm. long, 6 mm. wide, glabrous inside, the lobes *not* muricate; staminal column glabrous, as well as anthers, the lower only penicillate; fruit unknown. [PLATE 11.]

HAWAII: without definite locality, 1851–1855, *J. Remy 301*, type. Specimens are preserved in the herbarium of the Natural History Museum at Paris and in the Gray Herbarium.

The specimen in the Paris Museum, a photograph of which is here reproduced, is labeled *Rollandia* and *Delissea;* the duplicate in the Gray Herbarium is marked *Rollandia Humboldtiana* Gaud. That the species is not a *Rollandia* is evidenced by the free staminal column, while the absence of dorsal knobs would separate it from *Delissea*. The species belongs, in fact, to the section *Cyaneae genuinae* and comes exceedingly close to *Cyanea platyphylla* Hillbrd., differing in the long, narrowly oblong leaves and in the exceedingly long peduncles; otherwise the two species correspond closely.

The plant is named for Professor Fernald of the Gray Herbarium, to whom the writer is indebted for many favors received and especially for the loan of this particular species. The type is in the Gray Herbarium, Remy, No. 301. The writer had at first drawn up a description from the specimen in the Paris Museum, which is much better than the type specimen. Unfortunately the description was in some way lost after the specimen had been returned to Paris. Professor Fernald then sent me again the one in the Gray Herbarium, from which the description is drawn. The illustration represents the much more complete specimen in the Paris Museum. The writer had the Paris and Gray collections of Lobelioideae at his disposal for study at the same time, so there is no mistake in the identity of both specimens here in question.

4. **Cyanea Remyi** sp. nov.

Plant glabrous throughout; leaves thick, chartaceous, mostly 38–40 cm. long and 15 cm. wide, on petioles 10–12 cm. long; peduncle 7–8 cm. long, pedicels filiform, 1 cm. long; flowers (only a single flower bud remaining) purplish pink, glabrous, and of very thin texture. [PLATE 12.]

KAUAI or NIIHAU: without definite locality, 1851–1855, *J. Remy 302 bis*, type, in the herbarium of the Natural History Museum at Paris. The specimen is labeled *Delissea* but represents a typical *Cyanea*. The species has not again been collected and is very distinct. Nothing is known in regard to height or habit of growth.

5. CYANEA BISHOPII Rock, Indig. Trees Haw. Isl. 509. 1913.

Cyanea Kunthiana? Hillbrd. Fl. Hawaiian Isl. 264. 1888. Not *Delissea Kunthiana* Gaud.

MAUI: on the ridge overlooking Wailuku, back of Lahaina, West Maui, January, 1871, *E. F. Bishop*, type; slopes of Haleakala, wet forest between Waikamoi and Honomanu Gulch, along Kula pipe line trail in dense swampy jungle, west of Olinda, East Maui, at an elevation of 4200 feet, October, 1910, *J. F. Rock 8572* (fruiting specimens); May, 1911, *J. F. Rock 8806* (flowering specimens). Type specimens are preserved in the Gray Herbarium and in the herbarium at Berlin (PLATE 13); the other two specimens, which agree with the type, are in the herbarium of the College of Hawaii (PLATE 14).

With the type specimen in the Gray Herbarium is a letter addressed to Professor Asa Gray by Mr. Bishop, who writes as follows:

> I have recently come to East Hampton, June 15, 1872, from the Hawaiian Islands and have brought a few plants which I have collected. While there I had communication with Dr. Hillebrand who has made large collections. But he left for Germany where he intends publishing a work on the Island Flora. I have therefore some plants which are entirely new. All my collections have been made on West Maui.
>
> I enclose two plants herewith: a *Cyanea* found at an elevation of 4,000 feet. It was unfortunately not quite open but the buds are large and apparently of full size. The plant has a simple upright stem about 2 to 4 feet high. There are probably 10 to 15 full-sized leaves closely ranged at the apex of the plant. The specimen is full sized. Found January, 1871.

He then refers to the other plant, a *Hesperomannia;* at the foot of the letter is a note, probably written by Professor Gray, as follows: "Write and send the *Cyanea* to Hillebrand."

Hillebrand referred this plant doubtfully to *Cyanea Kunthiana* (Gaud.), a species figured but not described by its author* under the name *Delissea Kunthiana.* That it is not this species is evidenced by the fact that the lobes of the mature corolla are exceedingly short and retrorsely dentate or scabrous; the whole aspect, moreover, is different from the plant figured.

6. **Cyanea truncata** comb. nov.

Rollandia truncata Rock, Coll. Haw. Publ. Bot. Bull. 2: 44. 1913.

After careful reconsideration, while arranging the manuscript for his monograph on the Hawaiian Lobelioideae two years ago, the writer came to the conclusion that this species must be transferred to the genus *Cyanea.* The staminal column is free from the corolla and therefore belongs to *Cyanea,* even if the whole outward appearance is decidedly that of a *Rollandia.* It seems to furnish the intermediate between the two genera, as was pointed out by the writer in the original publication. *Cyanea Juddii* Forbes (Occ. Pap. Bish. Mus. 6: 3, 68. 1916) is probably identical with it. The type of the species is shown on PLATE 15.

7. **Cyanea angustifolia Hillebrandii** var. nov.

Cyanea angustifolia (Cham.) Hillbrd. Fl. Hawaiian Isl. 253. 1888 (in part).

A small, sparingly branching shrub 2 m. high, branches slender, glabrous; leaves ovate to ovate-oblong, 8–14 cm. long, 3–4 cm. wide, on petioles 2.5–3.5 cm. long, glabrous above, puberulous underneath, serrulate to crenulate, acute at both ends, peduncle very short, 1–1.5 cm. long; pedicels 5–10 mm. long, flowers as in the typical form of the species, only very small, 15 mm. long, 1.5 mm. wide.

MAUI: northern slopes of Mt. Haleakala, Keanae Valley, at an elevation of 1,000 feet, April, 1911, *J. F. Rock 8799* (flowering specimens), in the herbarium of the College of Hawaii.

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* Voy. Bonité *pl.* 77. 1839–52.

8. **Cyanea angustifolia lanaiensis** var. nov.

Cyanea angustifolia β. Hillbrd. *l. c.*

Plant 3–4 m. high, branching a few decimeters above ground, the branches erect and densely foliose at the apex; leaves dark green, membranous, glabrous on both sides, elongate-oblong, bluntly acute at the apex, rounded at the base, or slightly uneven-sided, coarsely serrâte with uncinate teeth, 10–18 cm. long, 4–5 cm. wide, on petioles 4.5–6 cm. long; racemes much shorter than in the typical form of the species, about 3.5 cm. long, few-flowered, flowers smaller, whitish.

LANAI: without definite localities, 1851–56, *J. Remy 304;* July, 1870, *W. Hillebrand;* Mahana Valley, July, 1910, *J. F. Rock 10257;* Kaiholena Valley, July, 1910, *J. F. Rock 8053.* The first specimen mentioned is in the herbarium of the Natural History Museum at Paris; the last two, in the herbarium of the College of Hawaii.

The variety *lanaiensis* differs from the typical form of the species in the broader leaves, rounded at the base and coarsely serrate with uncinate teeth; also in the short and few-flowered racemes.

9. **Cyanea ferox horrida** var. nov.

Cyanea ferox β var. Hillbrd. Fl. Hawaiian Isl. 259. 1888.

A branching shrub 18–22 dm. high branching usually at the base, trunk and branches covered with thorns; leaves all pinnatisect, crowded at the apex of the branches for about 25 cm., peduncles arranged all along the branches for about 25 cm., four to five flowered, bracteate at the apex, bracts 5 mm.; pedicels 10 mm., bracteolate at the middle; flowers unknown; berry ovoid, 20–25 mm., bright yellow, crowned by the calycine lobes.

MAUI: western slope of Mt Haleakala, in dense forest on the slopes of the crater Puukakai, at an elevation of 4,500 feet, along watercourses, quite abundant in company with *Cyanea hamatiflora* Rock, *Rubus hawaiensis* Gray, *Cyanea macrostegia* Hillbrd., etc., March, 1912, *Rock & Ceresole 10056* (fruiting specimens), in the herbarium of the College of Hawaii.

10. **Cyanea Grimesiana cylindrocalyx** var. nov.

Leaves pinnate at the base, pinnatisect towards the apex, the pinnae sinuately notched or lobed, the lobes denticulate; calyx tube long, cylindrical, 2.5–3.5 cm., including the ovarian portion, irregularly lobed, the lobes of uneven length from 4–10 mm., corolla more or less hidden in the calyx tube, dark purple; the upper anthers not bearded. [PLATE 16.]

HAWAII: Waipio Bay, December, 1851 (?), *J. Remy 309* (without flower or fruit), in the herbarium of the Natural History Museum at Paris; Waipio Valley (Waima branch), July 16, 1909, *J. F. Rock 4629* (flowering specimen), type, in the herbarium of the College of Hawaii.

A distinct variety, differing in the very shortly and unevenly lobed, cylindrical calyx, and in the upper anthers which are not bearded; the leaves are not openly pinnate, but closely pinnate in the lower portion and pinnatisect in the middle and upper portions of the leaf.

11. **Cyanea Hardyi** sp. nov.

A small tree 5–7 m. in height, with several straight ascending branches bearing large crowns of leaves at the apices; branchlets covered with leaf-scars; leaves narrow, linear-oblong, chartaceous, the margins crenulate to denticulate, denticulations close in the upper portion, coarser and wider apart in the second third, lacking at the base, midrib prominent underneath, the veins purplish, closely reticulate, dark green above, lighter underneath, 20–30 cm. long, 2.5–5 cm. wide, acuminate to acute at the apex gradually tapering into a margined petiole 2.5–8 cm. in length; racemes very slender, axillary, in the axils of the leaves and below the crown of leaves in the axils of the scars of fallen leaves, 20–25 cm. long, naked in the lower three fourths, minutely bracteate; the filiform pedicels bibracteolate at the middle; flowers deep purplish black, the calyx turbinate, strongly ribbed when dry, minutely toothed; corolla semi-curved, the dorsal slit extending to the middle, glabrous, anthers and staminal column glabrous, the lower anthers bearded; fruit unknown.

KAUAI: Olokele Canyon, at an elevation of 1400 feet, November, 1915, *W. V. Hardy 12767* (flowering specimens), type, in the herbarium of the College of Hawaii; Olokele Canyon, one mile from intake, October, 1916, *J. F. Rock 12765* (sterile specimens only); same locality, October, 1916, *A. P. Hitchcock 15242*, in the United States National Herbarium; below Kaholuamano, at an elevation of 2600 feet, October, 1916, *J. F. Rock 12766* (with undeveloped racemes).

The species is named in honor of Mr. W. V. Hardy, Assistant Engineer in the United States Hydrographic Survey.

In the College of Hawaii Publications, Botanical Bulletin 2, the writer stated that *Cyanea coriacea* (Gray) Rock was a very variable species and that the racemes in J. Remy's No. 302, preserved in the herbarium of the Natural History Museum at Paris, were not fully developed. This number was collected on the island of Kauai, in 1852, and a duplicate specimen preserved in the Gray Herbarium served as the type of *Delissea coriacea* Gray (*Cyanea coriacea* Rock). The species is characterized by thick, leathery, long-petioled leaves and by very short and stout racemes. It has recently been collected by W. V. Hardy in the Waioli River Basin, Kauai, at an elevation of 5000–7000 feet, this being the second known locality for the plant.

Another species of *Cyanea*, with racemes 7–22 cm. in length, is known to the writer from abundant material. It was originally collected by Hillebrand and referred by him to *Delissea coriacea* Gray. It was afterwards found by the Abbé Faurie and proposed as a new species by Léveillé under the name *Cyanea Fauriei*, the long racemes being emphasized in his description. This species is clearly distinct from *Delissea coriacea* and must stand as a good species.

In certain respects *C. Hardyi* is intermediate between *C. Fauriei* and *C. coriacea*. It differs mainly in its leaves, which are linear-oblong and acuminate, tapering gradually into a margined petiole. It is further characterized by its habit and by its dark purplish black inflorescence. In *C. Fauriei* the leaves are obovate-oblong, with longer petioles and abruptly cuneate at the base, the petioles not being margined; the inflorescence is pale lilac and more robust.

The following species, given in their natural order, range into each other and are consequently very closely related: *C. coriacea*, *C. Fauriei*, *C. Hardyi*, *C. spathulata* Rock, *C. angustifolia* (Cham.) Hillbrd., *C. comata* Rock, and perhaps *C. Mannii* Rock and *C. obtusifolia* Rock.

12. **Lobelia kauaiensis villosa** var. nov.

Stem 6–10 dm. high, covered with leaf-scars as in the typical form of the species, inflorescence branching candelabra-like, or a single spike about 55 cm. long and 1 cm. or more in diameter, villous-hairy throughout, light green in color; lower leaves oblong, sessile with a broad base, 9–14 cm. long, 3.5 cm. wide h thi prominent midrib and obscure venation, bluntly acute at the apex, glabrous below with the exception of the midrib and the entire margin, pubescent above, upper leaves gradually reduced to foliaceous, broadly ovate bracts; raceme more densely flowered than in the typical form, villous, the flowers arranged along the upper third of the spike, pedicels and calycine tube villous with whitish gray hairs, the calycine lobes green, but ciliate at the margin; corolla shorter than in the typical form but broader, whitish green, the veins very indistinct, only visible in the buds, slightly purplish tinged.

KAUAI: Mt. Waialeale, at an elevation of 5,000 feet, September 23, 1909, *J. F. Rock 5823a* (flowering specimens); October 21, 1916, *J. F. Rock & A. S. Hitchcock 12741* (also flowering specimens), type. Both specimens are preserved in the herbarium of the College of Hawaii.

A much stouter plant than the typical form of the species, differing in the broad, fleshy, oblong leaves, and broad, ovate bracts. The whole aspect of the plant is different; the typical form is glabrous and has dark purple, slender, glabrous racemes, while the racemes in the variety, which is almost worthy of specific rank, are thick, stout, bright green and villous throughout. The villosity and compact character of the plant are not due to location, for both the typical form and the variety grow side by side in the open bog of Mt. Waialeale on the island of Kauai, at an elevation of 5,000 feet, in company with Compositae, *Drosera longifolia* L., several species of *Plantago*, *Panicum monticola* Hook. f., *P. isachnoides* Munro, *P. imbricatum* Hillbrd. and *Oreobolus furcatus* H. Mann.

13. **Lobelia Gaudichaudii coccinea** var. nov.

Stem 3–7 dm. long, foliose at the apex, the single spike about 60 cm. long, leaves narrow, oblong, bluntly acute at the apex, narrowing at the base but sessile, 15–18 cm. long, about 1.5 cm. wide; the raceme open-flowered, glabrous throughout, flowers smaller than in the typical form of the species, glabrous, deep carmine red.

OAHU: summit of Mt. Konahuanui, on the very edge of the cliff overlooking Waimanalo, September, 1912, *Glen W. Shaw 12742* (flowering specimens), type; Mt. Lanihuli, September, 1914, *J. F. Nelson & J. Stone 10003* (flowering and fruiting specimens). Both specimens are preserved in the herbarium of the College of Hawaii.

This rather handsome plant is quite distinct from the true *Lobelia Gaudichaudii* DC., differing in the smaller deep red flowers, narrow lanceolate leaves with a pubescent midrib, and long, slender, loosely flowered, glabrous raceme.

COLLEGE OF HAWAII,
HONOLULU, TERRITORY OF HAWAII.

Explanation of plates 9-16

PLATE 9

Cyanea noli-me-tangere Rock. Photograph of the type specimen.

PLATE 10

Cyanea Copelandii Rock. Photograph of the type specimen, somewhat reduced.

PLATE 11

Cyanea Fernaldii Rock. Photograph of the specimen in the Paris Museum.

PLATE 12

Cyanea Remyi Rock. Photograph of the type specimen.

PLATE 13

Cyanea Bishopii Rock. Photograph of the specimen in the herbarium at Berlin.

PLATE 14

Cyanea Bishopii Rock. Photograph of East Maui specimen collected by the writer.

PLATE 15

Cyanea truncata Rock. Photograph of the type specimen.

PLATE 16

Cyanea Grimesiana cylindrocalyx Rock Photograph of the type specimen.

A critical study of certain species of Mucor*

ALFRED H. W. POVAH

(WITH PLATES 17–20)

I. INTRODUCTION

The Mucorales have been widely investigated in Europe for the past half century; consequently much has been written about them and many have been described. In this country, however, such has not been the case; for, with the exception of several papers on some of the rarer genera, Blakeslee's (1904) important publications on the sexual reproduction of the group comprise the only American contributions to a knowledge of these most interesting fungi. The Mucorales include a large number of forms, exhibiting considerable variation; in fact, the individual plants are quite plastic, so that we may obtain striking differences within the species under different external conditions, such as medium, light, temperature and moisture. It is, therefore, extremely desirable, when dealing with descriptions of species in this group, to have full data on the most important growth conditions. Thus far this fundamental fact has been under-emphasized in the work on the mucors, especially on the taxonomic side.

The object of the present work is an attempt to standardize and unify the genus *Mucor* with reference to the morphology of its individual species and their cultural reactions. The lack of a general knowledge of the physiological attributes of the many species which have hitherto been described makes it desirable to give these forms a detailed comparative study in order that some fundamental standard for their future classification may be obtained.

The investigations, upon which this paper is based, have been carried on during the years 1913, 1914, and 1915 in the Cryptogamic Laboratory of the University of Michigan under the direction of

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* Contribution No. 159 from the Botanical Department of the University of Michigan.

Dr. C. H. Kauffman, whose constant interest and helpful criticism are hereby gratefully acknowledged by the writer.

II. HISTORICAL

1. CULTURE METHODS

In De Bary's Morphologie und Physiologie der Pilze, Flechten und Myxomyceten (1866) the application of cultural methods to *Mucor* is mentioned for the first time, in the following words: "Sie [*Mucor Mucedo*] wächst spontan und in den Culturen auf faulenden Früchten, Speisen, Zuckerlösungen und besonders üppig auf Mist." To Brefeld (1872), however, belongs the honor of having been the first to realize the necessity of employing the single spore culture method. On page 25 of the first Heft of his Botanische Untersuchungen über Schimmelpilze, we read the following: "Der Weg der Cultur einer einzelnen Spore unter lückenloser Verfolgung ihrer einzelnen Entwicklungsmomente, unter Vermeidung der vielen und zahlreichen Fehlerquellen, wie sie durch Invasion fremder Pilzsporen entstehen, kann allein die Basis für die Kenntniss und Klassification dieser Schimmelpilze abgeben." His method was very simple. He placed on a slide a single spore in a drop of freshly prepared horse dung decoction. The slides were observed directly under the microscope and when not in use were kept on a zinc plate covered with a bell jar standing in water to keep the air moist. He undertook a study of *Mucor Mucedo* (De Bary says "at my instigation") in order to learn whether De Bary was correct in his "apparently irregular pleomorphy" conception of the "collective so-called *Mucor Mucedo*." As a result he found that De Bary, owing to his crude culture method, had been dealing with an impure culture, having introduced *Chaetocladium* into the cycle of *Mucor Mucedo.*

G. Klebs (1898) does not go into detail with regard to his culture methods, nor does he mention a single spore culture. He used, for media, those substances which had proved the most favorable for the mold he was studying (*Sporodinia grandis* Link). These he found to be bread soaked with plum juice, slices of carrot and plum juice agar.

Oudemans and Koning (1902), making a study of the mycological flora of the soil of the Netherlands, give their technique in detail. They used soil extract with 10 per cent. gelatin or 1.5 per cent. agar, but inasmuch as some fungi grew very slowly on these media, they added 2 per cent. of either saccharose or glucose. The following nutrient also proved very good in some cases: "wort 55, water 50," saccharose 2 per cent., gelatin 10 per cent., or agar 1.5 per cent. This medium always gave an acid reaction, but was used without neutralization. The manipulation may be outlined as follows: a fragment of humus from near the surface of the soil was introduced into a (previously sterilized) platinum crucible. About 1 c.c. of sterile water was then added, and the fragment of humus was triturated with a flamed glass rod, flattened at the end. A small amount of this infusion was transferred with a platinum loop to a test tube containing about 10 c.c. of water. The contents of the test tube were then emptied on a poured plate (Petri dish), which was inclined so as to allow the excess water to drain off. Their so-called pure cultures were made in one of the following ways: by cutting out a piece of the substratum with the organism on it; by transferring a fragment of the mycelium; or by transferring some spores to a newly poured plate.

In Hagem's (1908) method we are at once impressed with the fact that to him pure cultures from a single spore are prerequisites for any investigation. His method is as follows: with a platinum needle some spore material was transferred to a flask containing about 30 c.c. of sterile water. After a vigorous shaking to separate the spores, a few cubic centimeters of the dilution were poured into a second flask containing water. This was repeated once more and then 2 c.c. of this final dilution were poured into a Petri dish containing solid nutrient material, care being taken that the entire surface was moistened; the excess water was then poured off. After the cultures had stood for two or three days at room temperature, the cover of the Petri dish was removed and the plate was examined under the microscope for an isolated growth derived from a single spore. If such was found, it was cut out and transferred with a small amount of the substratum to a new dish. In his isolation of the soil-inhabiting forms, Hagem simply sprinkled a small amount of soil over three or four Petri dishes containing nutrient media. The one caution that he gives is that forms must be separated as soon as the sporangia are formed; otherwise small forms are overgrown by the larger and more rapidly growing ones.

Blakeslee (1904), in his epoch-making study on the Sexual Reproduction in the Mucorineae, demonstrates his skill as a master of culture technique. In addition to the usual methods of gross and single spore culture, he devised a novel procedure for isolation of the two (plus and minus) strains. This consisted in teasing out an immature zygospore and placing it on a nutrient suitable for growth. After many unsuccessful attempts he discovered cases in which growth from both suspensors occurred in sufficient amount so that they (both) could be transferred to a fresh culture. In his investigations he employed many different kinds of media among which may be mentioned fruits, egg, potato, milk, urine, and bread.

It is difficult to appraise Lendner's (1908) method, which he does not present in detail. Presumably he used single spore cultures, but in discussing his methods, although he speaks of "dilution methods in use in bacteriology," he makes no mention of a single spore method.

For isolating soil fungi, Jensen (1912) mentions several methods, among which is described an iron tube for taking soil samples. This, however, proved unavailable in frozen soil. Thus he dug a trench 24 x 10 x 12 inches deep, and after removing the soil from the side of the trench with a sterile scalpel, he transferred the earth sample with the reflamed scalpel to a wide-mouthed bottle. In plating out his soil samples he either transferred particles of soil to poured plates directly, or else he made dilutions and then inoculated the poured plates with this dilution. He examined the inverted plates under the microscope, and when a germinating spore was found, he marked its location with a drop of India ink, cut it out, and transferred it to a new plate.

As Bainier (1883) and Schostakowitsch (1896, 1897, 1898) do not discuss their culture method in any great detail, it is impossible to judge whether they used a single spore as a starting point for their cultures. Schostakowitsch appears to have used bread chiefly as a substratum, while Bainier mentions having employed horse dung and also various sugar solutions in addition to bread.

Sumstine's (1910) reference to his cultural data is so fragmentary that it is impossible to know anything besides the substrata that he used. Among these, the only nutrient, with the exception of horse dung and meat, is bread.

2. TAXONOMIC

Inasmuch as the early history of the genus *Mucor* has been given in detail by Fischer (1892), we shall begin with the work of De Bary (1866). The latter included in *Mucor* many forms which have subsequently been shown to be distinct. For example, he attributed "an apparently irregular pleomorphy of reproductive organs" to *Mucor Mucedo*, including and confusing with it not only *Chaetocladium* but also *Thamnidium*. These somewhat startling results, as we have seen before, are to be explained by the crude culture methods in vogue in his day.

Brefeld (1872) made an important contribution to the systematic study of the Mucorales by showing that the polymorphism of previous authors did not exist. He it was who first gave us a clear conception of *Mucor Mucedo*, although he (at least in his early writings) included *Sporodinia*, *Phycomyces*, *Rhizopus*, *Chaetocladium*, and *Chaetocladium* in the genus *Mucor*, recognizing only one other genus, viz., *Pilobolus*. However, after studying *Chaetocladium* and *Piptocephalis* in detail he decided that they were both generically distinct from *Mucor*.

Van Tieghem (1873, 1875) has contributed more to our taxonomic knowledge of the Mucorales than any other person, but practically all of his work lies outside the genus *Mucor*, he having described and named only two species, *Mucor plasmaticus* and *Mucor circinelloides*. His work, therefore, in so far as the genus *Mucor* is concerned, consisted in defining the genus by removing all the closely related genera that were confused with it at that time. In his second publication (1875) we have the only reference to his idea as to the determination of the species of the genus *Mucor*. He says: "Depuis plus de trois ans que je m'occupe de cette famille, j'ai étudié et cultivé plus de trent espèces de *Mucor*, et souvent encore j'en découvre de nouvelles. Elles se répartissent en quatre sections. Le filament sporangifère demeure, en effet, simple chez les unes, tandis que chez les autres il se ramifie latéralement après avoir produit son sporange terminal. Ensuite, suivant que, dans le premier, le filament sporangifère est doué ou non d'accroisement intercalaire, qu'il est élancé ou trapu, suivant que, dans le second, le ramification s'opère en grappe ou en cyme, chacun de ces deux groupes se partage à son tour en deux sections. La monographie de genre *Mucor* et la description détaillée des nombreuses espèces qui le constituent est donc un travail d'assez longue haleine, qui doit faire l'objet d'une publication spéciale."

Schröter (1889) did not recognize *Circinella*, *Rhizopus*, and *Spinellus* as genera, but regarded them as subgenera under *Mucor*. Under his subgenus *Eumucor*, which was the genus as we now consider it, he gave but seven species, which are reduced to five when considered from our present knowledge of the genus. In Engler and Prantl's Die natürlichen Pflanzenfamilien (1892) Schröter still retained his all too comprehensive genus *Mucor*, having added a fifth subgenus *Pirella*.

Saccardo (1888) included descriptions of some seventy-eight species of *Mucor*, of which less than ten are now recognized as authentic species of *Mucor*. His only separation, or attempt at such, was a division into two groups, the first of which contains those forms in which the sporangia are slightly colored at maturity; the second, those which have hyaline sporangia at maturity. Under the first division he included a subdivision containing forms with ovoid spores.

Fischer (1892) was the first to monograph the genus *Mucor*, giving twenty-one species with an analytical key. He first divided them into three sections, according to whether they were simple, monopodially or sympodially branched. These he again divided: the first section was subdivided according to the nature of the turf—whether remaining erect or soon collapsing; the second and third sections were subdivided according to their method of branching. Fischer, referring to his key, says that inasmuch as the species have not been studied thoroughly, "die folgende Zusammenstellung kann deshalb nur als eine provisorische betracht werden."

Schostakowitsch (1896, 1897, 1898), in his studies on the Siberian mucors, found nine species, seven of which were new to science. He found that *Mucor Mucedo* and *Mucor racemosus*, which were supposed to be of common occurrence throughout the world, grew seldom if at all in Siberia.

Although Bainier (1883*a*, 1883*b*, 1903) described sixteen new species of *Mucor*, only six of these can be identified from his fragmentary descriptions. Moreover, not more than two of the six species were completely described.

Blakeslee (1904), in dealing with the genus *Mucor*, merely designated his different forms with Roman numerals, of which I and II were homothallic forms and III to VI inclusive were species heterothallic.

Hagem (1908, 1910*b*), limiting himself to a study of the air- and soil-inhabiting forms in Norway, isolated seventeen species, of which seven were new. Although he retained *Zygorhynchus* as a genus, he did not treat *Rhizopus* in like manner, but reduced it to a "Subsectio" under *Mucor*. In his key he retains Van Tieghem's grouping into forms with simple, racemosely, and cymosely branched sporangiophores.

Lendner (1908) has satisfied a long-felt need in his publication. In the preface to his work we find that he has limited himself to a treatment of the genera which contain many recently described species. He recognizes fifty-one species under the genus *Mucor*, including *Glomerula repens* Bain., *Parasitella simplex* Bain., *Zygorhynchus Moelleri* Vuill., and *Zygorhynchus heterogamus* Vuill. under the names *Mucor Glomerula* Lendner (Bain.), *Mucor parasiticus* Bain., *Mucor Moelleri* Vuill., and *Mucor heterogamus* Vuill. respectively. He, himself, collected but eighteen species, of which seven were undescribed.

In his analytical key to the species of *Mucor*, Lendner used the arrangement of Fischer for his three large groups, viz.: (1) *Mono-Mucor* (comprising the unbranched forms), (2) *Racemo-Mucor* (branching in racemes or corymbs), (3) *Cymo-Mucor* (branching in sympodial cymes). Under the first division he includes ten species, which are arranged according to the morphological characteristics, such as height, color, size of sporangia, sporangium wall, shape of columella, spores, etc. In the second group he has twenty species, arranged in much the same fashion as in the first section. The third group is the largest, having one more species than the second. This section, for the most part, is divided in the same manner as the two previous ones, but in two places the author makes use of physiological characteristics as a basis for separation of species. In the first place, for example, he separates *Mucor Jansseni* from the remaining species by the fact that it grows poorly on "wort gelatin" but well on bread; in the second place, he separates *Mucor Rouxii* from the last four species by the fact that on either bread or "wort gelatin" it forms a short yellow down, while the remaining species form a turf 1–3 cm. tall.

Sumstine (1910), in his thirty page publication on the North American Mucorales, throws to the winds all the work of the late contributors to the group (Fischer, Hagem, Lendner, etc.). He separates from *Mucor* (Mich.) L., as ordinarily understood, the genera *Hydrophora* Tode (which had long been discarded for the name *Mucor*) and *Calyptromyces* Karst. (a genus founded merely on the fact that the sporangiophores are branched). In speaking of this last genus, Sumstine says: "This complex group contains some forty described species but the relationship of these species is not well known. There seem to be two modes of branching, monopodial and sympodial. This branching has been made the basis for the division into two groups, Racemo-Mucor and Cymo-Mucor. . . . This division, however, is uncertain and unsatisfactory." It is, in the writer's opinion, as unreasonable to maintain two genera, one for branching and the other for simple forms, as to separate species according to their mode of branching; for it has been found, during the course of this study, that the former distinction is practically as difficult as the one to which Sumstine objects. To give an idea of the confusion caused by the arrangement which this author proposes, let us consider a few cases. His *Mucor Mucedo* L. is the common *Rhizopus nigricans* Ehrenb., *Hydrophora stercorea* Tode is *Mucor Mucedo* Fresen., *Hydrogera obliqua* (Scop.) O. Kuntze is *Pilobolus crystallinus* (Web. & Wigg.) Tode, and *Calyptromyces ramosus* Karst. is *Mucor racemosus* Fresen. It is the writer's opinion that the only new things in this paper are names for plants which we fail to recognize under their new guise.

III. TECHNIQUE

1. COLLECTION OF MATERIAL

Collecting was begun in the autumn of 1913, when various kinds of dung, including that of the horse, cow, sheep, dog, rabbit, mouse, and squirrel, were brought into the laboratory, placed in moist chambers and watched for the development of mucors. Decaying plant material was also employed, and the following gave positive results: stems of decaying apple and grape (*Pyrus Malus* and *Vitis* sp.), mushrooms (*Collybia dryophila*, *Psalliota campestris*), wood and leaves (*Pinus sylvestris* and *Phlox* sp.), *Sphagnum* sp., tomato (*Lycopersicum esculentum*), carrot (*Daucus Carota*), Brazil nuts (*Bertholletia excelsa*), puff ball (*Calvatia* sp.), and oak root with mycorhiza. In the case of the plant material used, the material to be tested was placed in a damp chamber until there was produced a growth of mold sufficient to insure a transfer to a poured plate.

In the belief that the *Mucor* soil flora might prove interesting, the author undertook a series of isolations, which consisted in obtaining surface soil from a great variety of stations. These samples, except in the cases cited below, were all taken in the vicinity of Ann Arbor, Michigan. The following method was used: Petri dishes were wrapped in paper, sterilized, then taken to the field, where they were unwrapped and opened only long enough to fill them with soil. The cover was then replaced and sealed with a gummed label, upon which were written the collection data. At the laboratory the earth was saturated with sterile water, a drop or two of which was then transferred to a poured plate by means of a flamed platinum needle. From this culture a pure gross culture could usually be obtained, from which, in turn, a single spore culture was eventually made.

All of the forms isolated (see TABLE I), with the exception of Nos. 2, 4, 5, 6, 68, 69, 70, 71, and 72, were collected in the vicinity of Ann Arbor. The first four of these nine collections were obtained in Chippewa County, Michigan, during the summer of 1914; the rest were collected in the Adirondack Mountains, Hamilton County, New York.

For collecting in the field, it has been found most convenient to be provided with agar slants, and to make only rough cultures. In the case of soil forms a few small pieces of soil were placed, by means of a flamed platinum wire, in the tube; while in the case of coprophilus forms a gross transfer of hyphae with spores to the slant sufficed. These cultures were purified in the laboratory. TABLE I will give the data in a clear and concise manner.

TABLE I

COLLECTION DATA OF FORMS ISOLATED

No.	Date	Substratum	Species
1.	10/10/13.	Stem of decayed grape.	*Mucor griseo-lilacinus* sp. nov.
2.	7/ 9/14.	Decaying mushroom.	*Mucor Ramannianus* Moeller
3.	10/ 7/13.	Horse dung.	*Mucor griseo-lilacinus* sp. nov.
4.	8/19/14.	Porcupine dung.	*Mucor hiemalis* Wehmer
5.	8/15/14.	Bear dung.	*Mucor hiemalis* Wehmer
6.	7/13/14.	Moldy bone in woods.	*Mucor hiemalis* Wehmer
7.	10/12/13.	Horse dung.	*Mucor abundans* sp. nov.
8.	10/12/13.	Horse dung.	*Pilobolus longipes* Van Tiegh.
9.	10/27/14.	Sandy tilled soil, surface.	*Mucor abundans* sp. nov.
10.	11/18/13.	Horse dung.	*Mucor saturninus* Hagem
11.	10/19/13.	Sheep dung.	*Mucor griseo-lilacinus* sp. nov.
12.	11/20/13.	Squirrel (?) dung.	*Mucor griseo-cyanus* Hagem
13.	11/ 5/14.	Sandy wood soil, surface.	*Mucor hiemalis* Wehmer
14.	10/28/13.	Dung.	*Mucor abundans* sp. nov.
15.	3/14/14.	Rodent dung.	*Mucor griseo-lilacinus* sp. nov.
16.	10/23/13.	Horse dung.	*Mucor griseo-lilacinus* sp. nov.
17.	2/14/14.	Decaying wood.	*Absidia glauca* Hagem
18.	10/31/13.	Stem of decaying apple.	*Mucor varians* sp. nov.
19.	11/ 4/13.	Decaying tomato.	*Mucor abundans* sp. nov.
20.	2/19/14.	Decaying pine leaf.	*Mucor griseo-lilacinus* sp. nov.
21.	10/31/13.	Stable bedding and manure.	*Mucor varians* sp. nov.
22.	2/16/14.	Horse dung.	*Mucor abundans* sp. nov.
23.	1/31/13.	*Psalliota campestris.*	*Mucor griseo-lilacinus* sp. nov.
24.	11/22/13.	Dung.	*Mucor aromaticus* sp. nov.
25.	11/ 8/13.	Horse dung.	*Mucor abundans* sp. nov.
26.	11/20/13.	Dung.	*Mucor griseosporus* sp. nov.
27.	11/18/13.	Horse dung.	*Helicostylum piriforme* Bain.
28.	11/20/13.	Dog dung.	*Mucor abundans* sp. nov.
29.	11/22/13.	Decaying *Calvatia* sp.	*Mucor varians* sp. nov.
30.	11/27/13.	Old bones.	*Mucor griseo-cyanus* Hagem
31.	11/22/13.	Rabbit dung.	*Mucor abundans* sp. nov.
32.	11/22/13.	Dung.	*Mucor abundans* sp. nov.
33.	11/20/13.	Squirrel (?) dung.	*Mucor abundans* sp. nov. and *Chaetocladium Brefeldii* Van Tiegh.
34.	11/20/13.	Dung.	*Mucor proliferus* Schostak.
35.	10/23/14.	Oak root with mycorhiza.	*Mucor lamprosporus* Lendner
36.	10/27/14.	Surface soil, hardwoods.	*Mucor varians* sp. nov.
37.	10/24/14.	Soil below surface, hardwoods.	*Mucor varians* sp. nov.
38.	10/27/14.	Surface, tilled soil.	*Mucor circinelloides* Van Tiegh.
39.	10/27/14.	Soil below surface in corn field.	*Mucor circinelloides* Van Tiegh.
40.	11/ 5/14.	Soil below surface in U. of M. Botanical Garden.	*Glomerula repens* Bain.

TABLE I—*Continued*

No.	Date	Substratum	Species
41.	11/ 5/14.	Sandy surface soil at edge of thicket.	*Zygorhynchus Vuillemini* Namysl.
42.	11/ 5/14.	Soil in greenhouse.	*Mucor circinelloides* Van Tiegh.
43.	11/ 5/14.	Soil from cold frame.	*Mucor circinelloides* Van Tiegh.
44.	11/ 5/14.	Soil in greenhouse.	*Mucor spinescens* Lendner
45.	11/ 5/14.	Soil in cold frame.	*Mucor circinelloides* Van Tiegh.
46.	11/ 5/14.	Surface soil in U. of M. Botanical Garden.	*Mucor varians* sp. nov.
47.	10/17/14.	Contamination in culture.	*Mucor plumbeus* Bonord.
48.	10/17/14.	Contamination in culture.	*Mucor christianiensis* Hagem
49.	10/17/14.	On decayed leaf.	*Mucor sphaerosporus* Hagem
50.	11/ 2/14.	Contamination in culture.	*Mucor sphaerosporus* Hagem
51.	10/ 6/14.	Decayed phlox leaf.	*Mucor plumbeus* Bonord.
52.	10/ 7/13.	Horse dung.	*Phycomyces nitens* (Agardh) Kunze
53.	11/23/14.	Contamination.	*Thamnidium elegans* Link
54.	11/10/14.	Soil in greenhouse.	*Mucor christianiensis* Hagem
55.	11/ 5/14.	Soil below surface in U. of M. Botanical Garden.	*Cunninghamella elegans* Lendner
56.	11/ 5/14.	Same data as No. 55.	*Mucor circinelloides* Van Tiegh.
57.	10/27/14.	Same data as No. 39.	*Mucor corticolus* Hagem
58.	10/27/14.	Same data as No. 39.	*Mucor varians* sp. nov.
59.	11/ 5/14.	Soil in greenhouse.	*Mucor christianiensis* Hagem
60.	11/ 5/14.	Same data as No. 46.	*Mucor abundans* sp. nov.
61.	3/25/15.	*Sphagnum* with germinating seeds.	*Mucor plumbeus* Bonord.
62.	4/ 7/15.	Decayed carrot.	*Mucor Ramannianus* Moeller
63.	3/25/15.	Decaying bean testas.	*Glomerula repens* Bain.
64.	6/ 5/15.	Contamination.	*Rhizopus arrhizus* Fisch.
65.	3/21/15.	Filter paper with date seeds in damp chamber.	*Syncephalis* sp.
66.	4/ 8/15.	*Pilobolus* sp.	*Syncephalis cornu* Van Tiegh. & Le Monn.
67.	4/ 8/15.	Horse dung.	*Mucor hiemalis* Wehmer
68.	8/17/15.	Decaying *Collybia dryophila*.	*Mucor saturninus* Hagem
69.	8/31/15.	Soil in mixed woods.	*Absidia caerulea* Bain.
70.	8/31/15.	Soil in mixed woods.	*Mucor corticolus* Hagem
71.	8/31/15.	Soil in mixed woods.	*Absidia glauca* Hagem
72.	8/31/15.	Soil in mixed woods.	*Mucor hiemalis* Wehmer
73.	3/12/15.	Rabbit dung.	*Mucor coprophilus* sp. nov.
74.	3/12/15.	Woodchuck (?) dung.	*Mucor hiemalis* Wehmer
75.	1/22/16.	Decayed Brazil nut.	*Mucor spinescens* Lendner
76.	1/16/15.	Fruit of *Kigelia pinnata* (brought from Java, 7/14).	*Mucor corticolus* Hagem
77.	1/22/16.	Decayed Brazil nut.	*Mucor christianiensis* Hagem
78.	1/22/16.	Decayed Brazil nut.	*Mucor plumbeus* Bonord.
79.	1/22/16.	Decayed Brazil nut.	*Rhizopus nigricans* Ehrenb.
80.	1/22/16.	Decayed Brazil nut.	*Circinella spinosa* Van Tiegh. & Le Monn.
81.	10/19/13.	Sheep dung.	*Pilobolus crystallinus* (Wig.) Tode
82.	10/31/13.	Stable bedding and dung.	*Pilobolus oedipus* Montagne
83.	3/26/14.	*Sphagnum* with germinating castor beans.	*Mucor botryoides* Lendner
84.	8/17/14.	Decaying mushroom.	*Sporodinia grandis* Link

2. .ISOLATION

As a rule little difficulty was experienced in obtaining a pure gross culture, one or two transfers to poured plates usually sufficing to eliminate obvious contaminations. In a series of closely related forms, however, there is no certainty of a pure culture, unless the latter has originated from a single spore. For practically all purposes a medium of the following composition per liter was used:

Ammonium nitrate	1.0 gm.
Dihydrogen potassium phosphate	0.5 gm.
Peptone	0.5 gm.
Magnesium sulphate	0.25 gm.
Cane sugar	5.0 gm.
Agar agar	13.0 gm.

The advantage of this medium is that all forms tried have been found to grow on it, and that cultures kept on it through the summer months (June–September) retain their vitality, at least when kept in a cool place. For stock cultures the writer has lately used a formula given him by Blakeslee, viz.:

Agar agar	2.0%
Peptone (Witte)	0.1%
Dextrose	2.0%
Dry malt extract (Eimer & Amend)	2.0%

This agar gives a much more luxuriant growth than the first-mentioned medium, but its use for keeping cultures longer than six weeks has not been tried by the writer.

Single spore cultures were made by a modified Kauffman's (1908) method, which is essentially an isolation of a single spore by spraying a spore dilution on a poured plate. Capillary pipettes were made, fitted with a tiny loose-fitting cotton plug immediately below the nipple. These were then sterilized in a device made as follows: two pieces of corrugated sheet asbestos, two decimeters square, were fastened together with wire in such a way that the ridges met so as to form a series of tubes between the two pieces of asbestos. The pipettes, minus the rubber nipples, were then inserted in these tubes and the apparatus was placed on a tripod over a burner and heated. Later, after the apparatus had cooled, the rubber nipples were replaced very carefully to avoid displacing the sterile air in the pipettes.

Spore dilutions were made by transferring some spore material with a platinum wire to test tubes containing about twenty cubic centimeters of sterile water each. This dilution was then sprayed on poured plates, and if the pipettes were fine enough and the spores diluted sufficiently, it was always possible to find a single spore isolated from the rest. After ten to sixteen hours, depending upon the temperature, the plates were examined to note whether germination had taken place. For this purpose the Petri dish was inverted on the stage of the microscope and examined with the low power. If a solitary germinated spore was found, the location was marked with a drop of India ink, and later the spore, together with a tiny block of agar, was cut out by a spear-pointed needle and transferred to a new poured plate. The writer has always made it a practice to watch these cultures carefully and as soon as possible to make a transfer from the edge of the growth, in order to avoid the possibility of contamination through a neighboring spore delayed in germination. This last transfer was usually made within twenty-four hours after the spore had been removed. It seems almost unnecessary to add that all the cultures used have originated from single spore cultures made in the above-described manner.

3. HERBARIUM MATERIAL

In addition to depositing living cultures in the Cryptogamic Laboratory of the University of Michigan, a series of herbarium specimens was also prepared. Inasmuch as the method employed may prove useful to others it seems desirable to include it here. For the cultures, tall lipless beakers (500 c.c. capacity) were used, with a depth of about 3 cm. of bread. If fresh bread was used, no water was added, but if dried bread was used, water was added until the medium had the humidity of the former. For a cover half of a Petri dish was fitted with a thin layer of cotton batting, and then the preparations were autoclaved for three or four hours at fifteen pounds pressure.

Pure cultures were employed for inoculation, and then the cultures were placed in the dark, in order to secure a symmetrical development. The cultures were allowed to stand, not only until the maximum growth had taken place, but until the cultures were thoroughly dried out, in the course of which process the medium and fungus had contracted and shrunk away from the glass. Thus it was a simple matter to remove them intact. Each specimen was glued to the bottom of a cardboard box, measuring 4½ x 3½ x 1¼ inches, the cover of which was fitted with a celluloid "window" 3½ inches long and 2¼ inches wide. It is believed that with careful handling specimens prepared in this way will retain their characters for a long time. This opinion is not without evidence to support it, as the writer has examined some of his specimens which had been kept dry for one and one half years and also Ellis & Everhart's North American Fungi, Nos. 2454 and 972. In all cases the material was in such condition that its identity could be determined with certainty.

IV. EXPERIMENTAL

The experimental work was undertaken in the hope that the results, supplemented by the morphological characters, might form a basis for the separation of species. It was desired to know whether forms morphologically similar would react similarly to the same cultural conditions, and whether forms whose morphology might lead us to believe them distinct might exhibit, or manifest, their close affinity in their cultural characteristics under the same conditions. Such has been found true only to a certain degree, but the results of the experiments are believed to be of value in the taxonomic part of this study. Consequently, experimental data have been freely used in the commentary on the individual species.

A uniform system of tabulation has been used throughout the series of experiments, in order to admit of easy comparison and also to avoid unnecessary confusion. The numbers given in the first column of TABLE I are used in all succeeding tables and throughout the work in the same way. It will be noticed in TABLES II and III that for each *Mucor* number there are two columns, the first containing Arabic, and the second Roman numerals. The former gives the height (length of sporangiophores) in millimeters, the latter the growth (judged by mass appearance), IV being excellent, III good, II fair, and I poor. It should be added that the presentation of results has been condensed on account of lack of space; hence, in the case of each medium, only the maximum growth is given irrespective of time. Furthermore, in any consideration of the numbers in the tables, it must be borne in mind that these numbers are liable to be misleading when interpreted from a standpoint of medium exclusively, because they include the inherent tendency of the species. To be specific, *Mucor griseosporus* has been found by the writer to be more plastic than other species; for example, it varies from 8 mm. to 20 mm. in height according to the medium used, while *Mucor spinescens* is always a low-growing form, heights varying only from 2 mm. to 8 mm. having been obtained.

TABLE II

HEIGHT AND GROWTH OF MUCORS WITH MISCELLANEOUS GELATIN MEDIA

Media	*Mucor* No. 34		*Mucor* No. 5		*Mucor* No. 4		*Mucor* No. 1		*Mucor* No. 7		*Mucor* No. 40		*Mucor* No. 16		*Mucor* No. 12		*Mucor* No. 21		*Mucor* No. 44	
	Ht.	G.	Ht.	G.	Ht.	G.	Ht.	G.	Ht.	G.	Ht.	G.	Ht.	G.	Ht.	G.	Ht.	G.	Ht.	G.
Levulose	35	IV	15	III	15	III	15	III	15	III	15	III	15	III	10	II	5	II	8	II
Dextrine	35	IV	15	III	15	III	15	III	15	III	15	III	15	III	8	II	5	II	8	II
Glucose (*a*)	25	IV	17	III	16	III	15	III	14	III	15	III	12	III	10	II	9	II	3	I
Glucose	30	IV	12	III	11	III	10	III	13	III	12	III	10	III	4	II	7	II	6	I
Dung ext.	20	IV	17	III	20	III	12	III	20	III	8	II	5	II	9	II	5	II	5	I
Raulin (*a*)	30	IV	11	III	11	III	15	III	5	II	18	III	8	II	5	II	9	III	3	I
Maltose	20	IV	12	III	11	II	9	III	4	III	11	III	10	III	6	II	5	II	5	I
Lactose	20	IV	10	II	15	III	15	III	8	III	5	II	4	II	3	II	5	II	3	I
Beef broth	36	II	12	II	14	II	11	II	9	II	7	II	9	I	9	II	8	I	5	I
Inulin	10	III	8	II	12	II	8	II	10	II	5	II	8	II	7	II	3	II	3	I
Sucrose	—	—	—	—	11	III	5	II	10	III	9	II	5	II	5	II	5	II	2	I
Inorg. salts	—	—	—	—	9	II	5	II	8	II	5	II	4	II	3	II	4	II	2	I
Check	—	—	—	—	9	II	5	II	7	II	5	II	—	—	3	II	4	II	5	I

In the early experiments gelatin was used as the culture medium, but later this was replaced by agar, as the latter was found to serve the purpose equally well and, moreover, there is less possibility of its liquefaction. The following were the formulae used as given in abbreviated form in the first column of TABLE II: levulose, dextrin, glucose, maltose, lactose, inulin, and sucrose, in each case 2 per cent. of the carbohydrate with 12 per cent. gelatin; glucose (*a*), 5 per cent. glucose, gelatin 15 per cent. and one drop of 10 per cent. lactic acid; dung extract, fresh horse dung extracted with cold water and 15 per cent. gelatin; Raulin (*a*), Lendner's (1908) formula with substitution of glucose for sucrose; beef broth, 0.75 gm. Armour's beef extract, 50 gm. gelatin and 500 c.c. water; inorganic salts, 1.0 gm. KNO_3, 0.5 gm. KH_2PO_4, 0.25 gm. $MgSO_4$, 0.5 gm. $CaCl_2$, 100 gm. water, and 12.0 gm. gelatin; check, 12 per cent. gelatin with distilled water.

In this experiment the cultures were made in test tubes and about 5 c.c. of the medium were used. The cultures were kept in the dark at room temperature (15–22 degrees C.). All cultures were made in duplicate, and in many cases, where there was a doubt in the mind of the writer, the experiment was repeated. The results are best obtained by consulting TABLE II, from which we see that levulose is the best medium in this series, followed by dextrin, glucose (acid), glucose, dung extract, Raulin's (acid) in the order named. Sucrose is the poorest, probably because many of the forms are unable to invert it.

TABLE III

HEIGHT AND GROWTH OF MUCORS WITH MISCELLANEOUS AGAR MEDIA

Media	*Mucor* No. 26		*Mucor* No. 34		*Mucor* No. 5		*Mucor* No. 24		*Mucor* No. 28		*Mucor* No. 6		*Mucor* No. 51	
	Ht.	G.	Ht.	G.	Ht.	G.	Ht.	G.	Ht.	G.	Ht.	G.	Ht.	G.
Rolled oats	70	IV	68	IV	42	IV	30	IV	40	IV	45	IV	10	IV
Glucose-asparagin agar	50	IV	27	IV	30	IV	18	IV	23	IV	24	IV	10	IV
Potato agar	65	III	55	IV	37	IV	32	IV	21	III	22	III	10	III
Corn meal	65	IV	60	III	35	III	20	III	30	III	25	III	5	III
Bread	40	III	60	III	10	III	25	III	25	III	15	III	10	III
Rice	50	IV	40	III	25	III	20	III	20	III	20	III	8	II
Glucose-nitrate agar	40	III	8	III	27	IV	13	III	17	III	19	III	13	III
Mannit-asparagin agar	25	II	9	III	22	III	15	III	11	III	6	II	10	III
Wheat-starch paste	50	III	25	II	25	III	20	III	20	II	20	III	10	II
Grapefruit	21	II	3	II	19	II	15	II	18	II	10	II	5	II
Sucrose-asparagin agar	38	II	5	I	14	II	20	II	7	II	5	II	9	II
Navy bean agar	27	II	33	II	13	II	20	III	9	I	8	II	5	I
Sucrose-nitrate agar	40	II	4	I	15	I	11	I	5	II	5	I	7	I
Mannit-nitrate agar	20	I	25	I	8	I	13	II	1	I	0	0	6	I
Apple agar	40	I	10	I	5	I	11	I	5	I	10	I	5	I
Prunes	1	I	1	I	10	II	1	I	1	I	—	I	1	I

In the next series of experiments various agar and complex media were used. See TABLE III. An explanation of the formulae of these media follows. Potato agar was made according to the method given by Thom (1905), and apple agar was prepared in the same way. For bean agar Thom's (1910) formula was used. For glucose-, mannit-, and sucrose- asparagin agar, and for glucose-, mannit-, and sucrose-nitrate agar, a combination of mineral salts (0.25 gm. $MgSO_4$, and 0.5 gm. KH_2PO_4) was used with 5.0 gm. of the carbohydrate, and 1.0 gm. of either ammonium nitrate or asparagin. Rolled oats and wheat starch were both used with water in the proportion of 1 : 2 parts water by weight; corn meal was used with equal parts of water. Bread was used in the same manner as previously mentioned. Rice was used with three parts of water. Only the pulp and juice of the grapefruit were used. In the case of prunes, about one fourth of a prune was moistened with 5 c.c. of water. The results are given in TABLE III.

From this table we see that the best growth occurs on rolled oats, and that of the six best media, five are complex substances, while the sixth—glucose-asparagin agar—contains an available carbohydrate and an organic nitrogen compound. A comparison of the results obtained with glucose-asparagin agar and glucose-nitrate agar shows that the former is a more favorable medium. This is due to the form of the nitrogen offered the plant, and this nitrogen source is probably one of the important reasons why complex media are more suitable for these forms. Mannit with asparagin is better than sucrose with asparagin, but sucrose with nitrate is a better combination than mannit with nitrate. This is in accord with Jost's (1907) statement that the quality of the nitrogenous material has an influence on the nutritive value of any particular carbon compound. The growth on grapefruit was fair, while that on prunes was poor. This last result was, in all probability, due to the fact that the medium contained too high a percentage of sugar. This hypothesis is borne out by the fact that in practically all cases in which growth occurred, only a sterile mycelium developed. It should be mentioned in connection with the use of rice that, in order to determine whether there would be any difference in results with rice from different places, an experiment was set up with fifty-three numbers of mucors, using rice from different sources, purchased in Detroit and in Ann Arbor. The results showed no appreciable difference.

It seemed advisable, from the results obtained in the first two series of experiments, to select certain media and test them with a larger number of forms. Consequently a series of cultures was made with rice, bread, and grapefruit, including a large number of mucors. The height of the cultures is given in TABLE IV.

An interesting feature of the cultures on rice was the frequent occurrence, on the surface of the medium around the edges of the culture, of a bright-colored line; this is pinkish to light orange yellow (Ridgway, 1912). Data on sixty-four numbers of *Mucor* show that thirty-four exhibited this color production, while twenty-eight numbers (Nos. 9, 10, 12, 24, 25, 26, 30, 34, 35, 38, 40, 41, 42, 44, 46, 48, 49, 50, 51, 54, 58, 59, 61, 62, 63, 68, 73, and 2) formed no color at the top of the substratum.

TABLE IV

HEIGHT OF MUCORS ON BREAD, RICE, AND GRAPEFRUIT

Species used	Rice	Bread	Grape-fruit	Species used	Rice	Bread	Grape-fruit
Mucor No. 1....	15	15	12	*Mucor* No. 36....	30	10	13
Mucor No. 2.. .	2	2	0.5	*Mucor* No. 37....	30	20	8
Mucor No. 3....	20	8	11	*Mucor* No. 38....	20	10	17
Mucor No. 4....	20	30	17	*Mucor* No. 39....	30	15	15
Mucor No. 5....	25	15	19	*Mucor* No. 40....	20	40	11
Mucor No. 6....	20	15	10	*Mucor* No. 41....	20	5	4
Mucor No. 7....	30	20	12	*Mucor* No. 42....	15	4	2
Mucor No. 9....	35	8	13	*Mucor* No. 43....	35	12	11
Mucor No. 10....	10	25	14	*Mucor* No. 44....	3	4	3
Mucor No. 11....	13	10	13	*Mucor* No. 45....	30	13	12
Mucor No. 12....	20	6	10	*Mucor* No. 46....	25	12	11
Mucor No. 13....	10	—	10	*Mucor* No. 47....	—	5	4
Mucor No. 14....	30	20	13	*Mucor* No. 48....	—	4	3
Mucor No. 15....	15	7	8	*Mucor* No. 49....	10	—	8
Mucor No. 16....	15	10	15	*Mucor* No. 50....	20	17	7
Mucor No. 18....	30	12	15	*Mucor* No. 51....	8	10	5
Mucor No. 19....	35	10	10	*Mucor* No. 54....	5	3	10
Mucor No. 20....	20	8	12	*Mucor* No. 56....	30	6	12
Mucor No. 21....	30	35	11	*Mucor* No. 57....	20	12	11
Mucor No. 22....	35	10	13	*Mucor* No. 58....	25	15	12
Mucor No. 23....	10	—	9	*Mucor* No. 59....	10	8	4
Mucor No. 24....	30	25	15	*Mucor* No. 60....	35	12	15
Mucor No. 25....	25	10	7	*Mucor* No. 61....	7	3	5
Mucor No. 26....	50	40	21	*Mucor* No. 62....	3	2	—
Mucor No. 28....	25	25	18	*Mucor* No. 63....	20	15	10
Mucor No. 29....	30	22	12	*Mucor* No. 67....	15	—	10
Mucor No. 30....	15	9	12	*Mucor* No. 68....	20	20	20
Mucor No. 31....	20	20	13	*Mucor* No. 70....	—	10	12
Mucor No. 32....	25	11	15	*Mucor* No. 72....	10	10	10
Mucor No. 33....	25	15	15	*Mucor* No. 73....	30	25	25
Mucor No. 34....	40	60	3	*Mucor* No. 74....	15	3	10
Mucor No. 35....	25	12	17	*Mucor* No. 76....	25	—	17

From the preceding experiments it has been shown that complex media are, on the whole, better for these plants than simple media, and as bread is a universally staple article easily obtained, as well as easy to work with, it has been used as a standard medium to grow these forms for taxonomic study.

A series of sixty-five numbers of *Mucor* (including all the species of *Mucor* collected with the exception of *Mucor botryoides*) was tested for their ability to ferment a dextrose, peptone solution (dextrose 10 per cent., peptone 0.1 per cent.) with positive results, except in the case of *Mucor Ramannianus*.

Because certain organisms have the ability to change tyrosin, by the production of an enzyme, into a dark-colored compound, often accompanied by the production of a brownish black precipitate, it was decided to use this organic compound with a series of mucors. For this experiment a solution of the following composition was employed: maltose 2 per cent., peptone 0.1 per cent., tyrosin 0.015 per cent. (1 gm. tyrosin to 6,400 c.c. of solution). The same mucors which were used in the preceding experiment were also employed for this series. The results may be given in the following brief manner. Four (Nos. 22, 36, 57, and 67) were discarded on account of bacterial contamination. In Nos. 4, 5, 6, and 72 there developed an apricot yellow (Ridgway) submerged mycelium, the color being due to yellow globules in the hyphae. The following showed a slight production of yellow color in the submerged hyphae: Nos. 1, 3, 7, 9, 11, 12, 13, 14, 15, 16, 18, 19, 20, 21, 25, 28, 29, 31, 32, 33, 37, 38, 39, 42, 43, 56, 58, 60, 74, and 76. No color formation was found in Nos. 2, 10, 23, 24, 30, 34, 41, 44, 45, 46, 47, 48, 49, 50, 51, 54, 59, 61, 68, and 70. There was a marked coloration of the solution, with the formation of a dark brown precipitate, in Nos. 26 (*Mucor griseosporus*) and 73 (*Mucor coprophilus*), the color of the solution in each case being dark reddish brown. In Nos. 34, 44, 51, and 61, the solution was colored pale brown, and a dark brownish black precipitate was formed. In Nos. 40 and 63 (both *Glomerula repens*) there was a brownish tinge to the solution, and the aerial growth was distinctive in that it was pinkish buff (Ridgway).

[*To be concluded.*]

INDEX TO AMERICAN BOTANICAL LITERATURE

1916-1917

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the word America being used in the broadest sense.

Reviews, and papers that relate exclusively to forestry, agriculture, horticulture, manufactured products of vegetable origin, or laboratory methods are not included, and no attempt is made to index the literature of bacteriology. An occasional exception is made in favor of some paper appearing in an American periodical which is devoted wholly to botany. Reprints are not mentioned unless they differ from the original in some important particular. If users of the Index will call the attention of the editor to errors or omissions, their kindness will be appreciated.

This Index is reprinted monthly on cards, and furnished in this form to subscribers at the rate of one cent for each card. Selections of cards are not permitted; each subscriber must take all cards published during the term of his subscription. Correspondence relating to the card issue should be addressed to the Treasurer of the Torrey Botanical Club.

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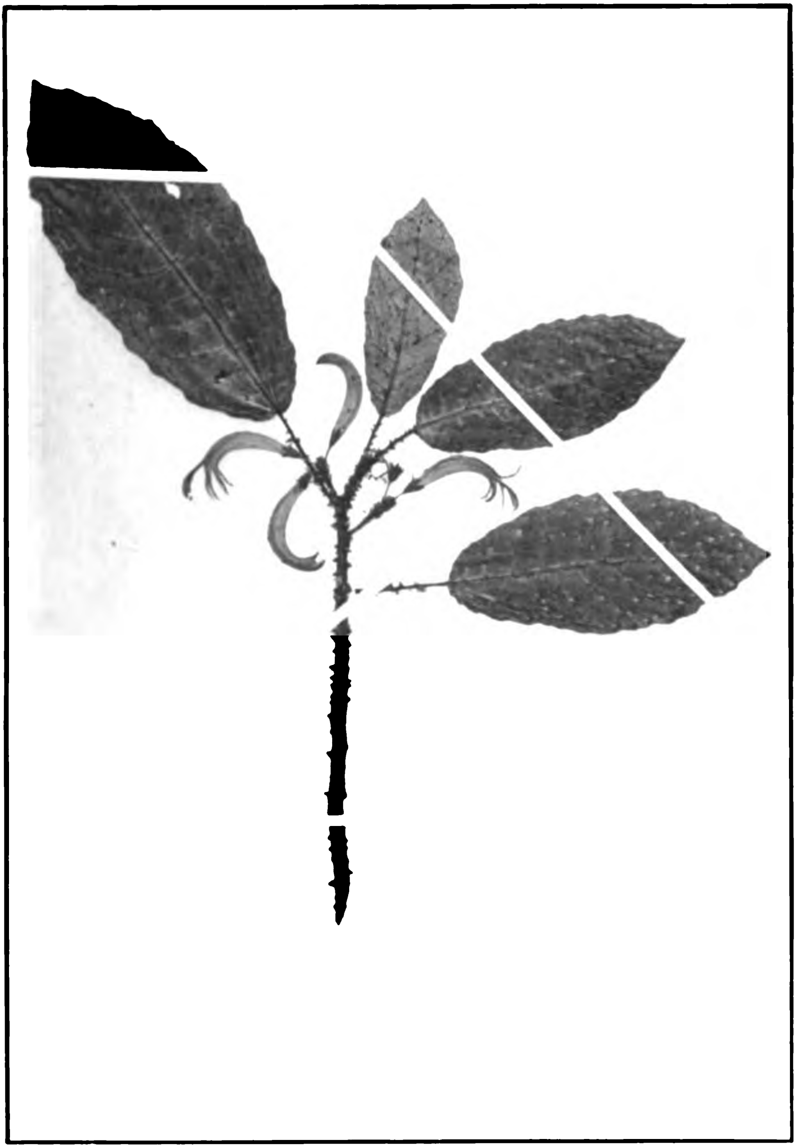

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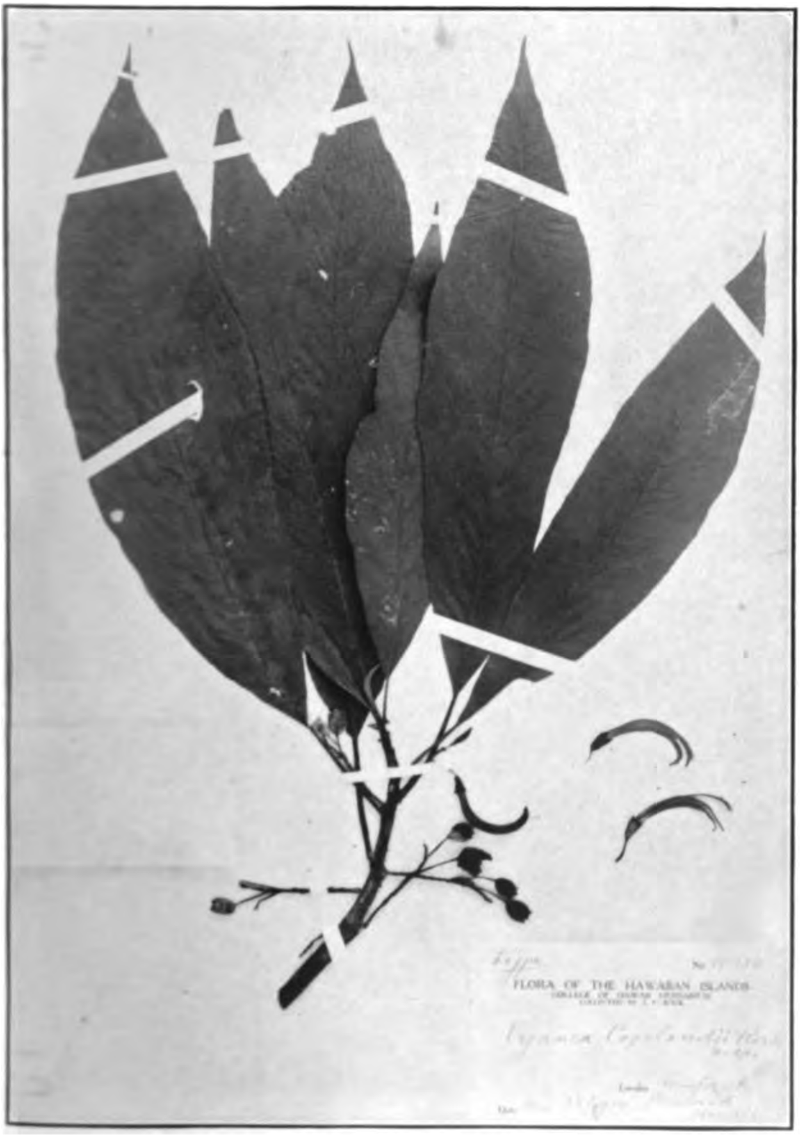

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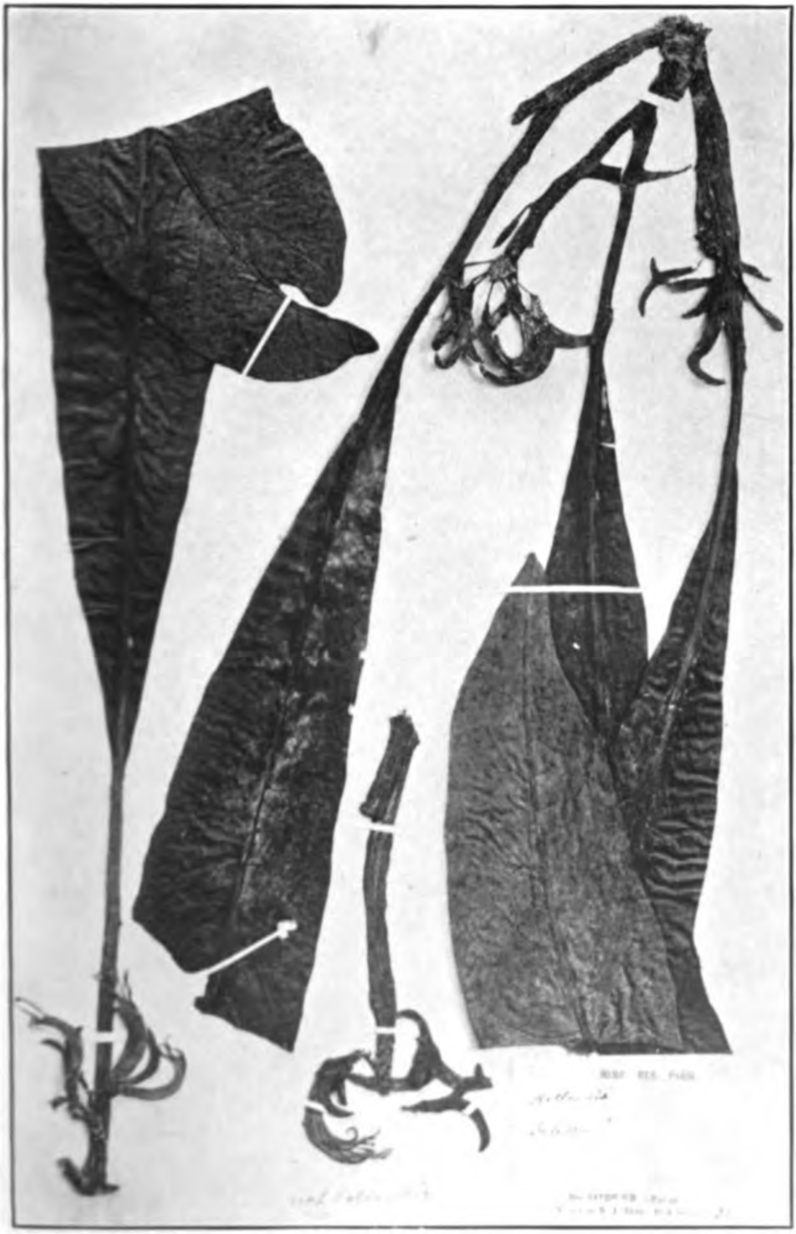

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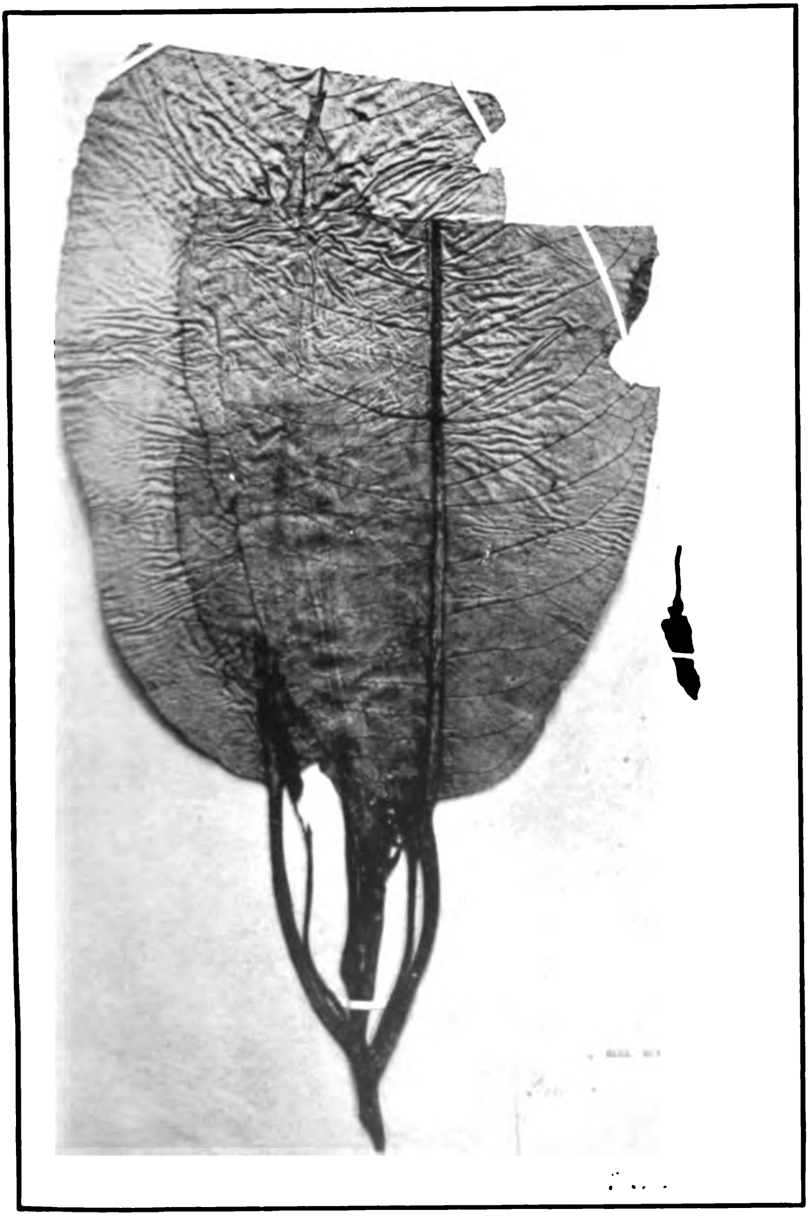

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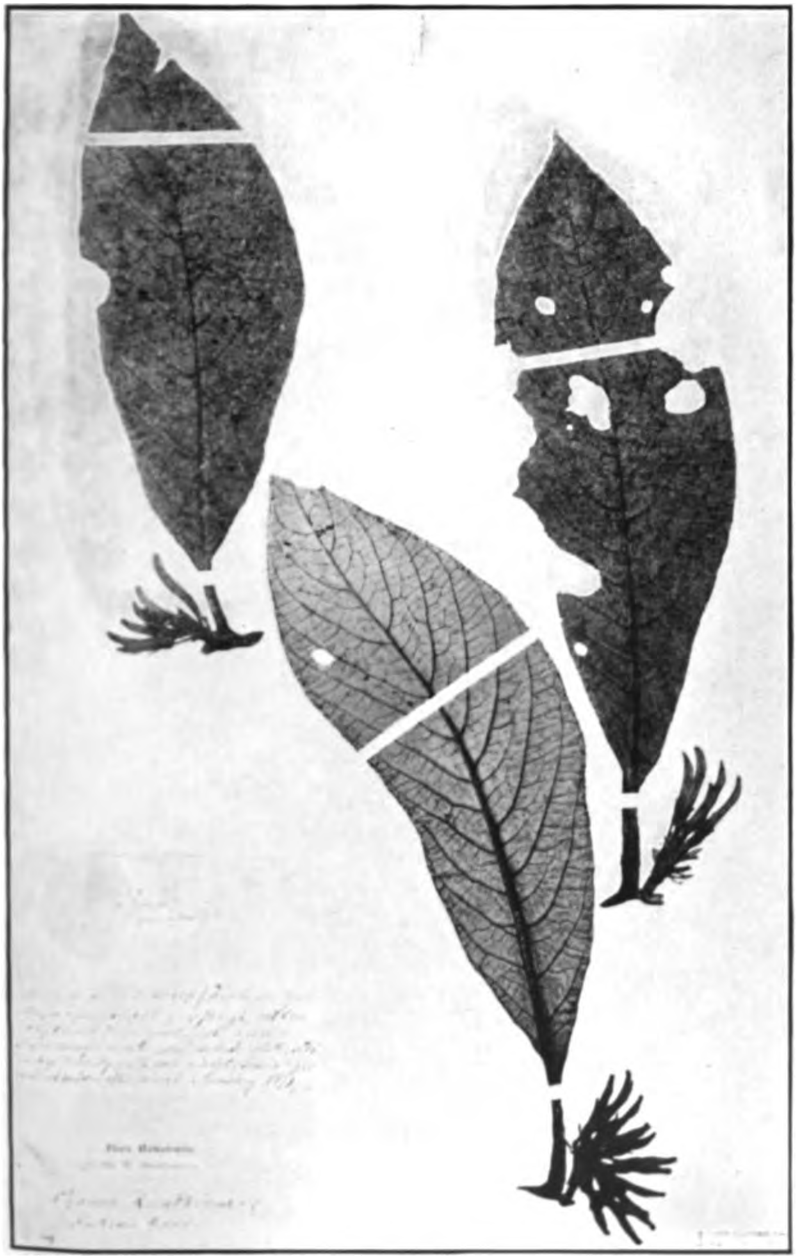

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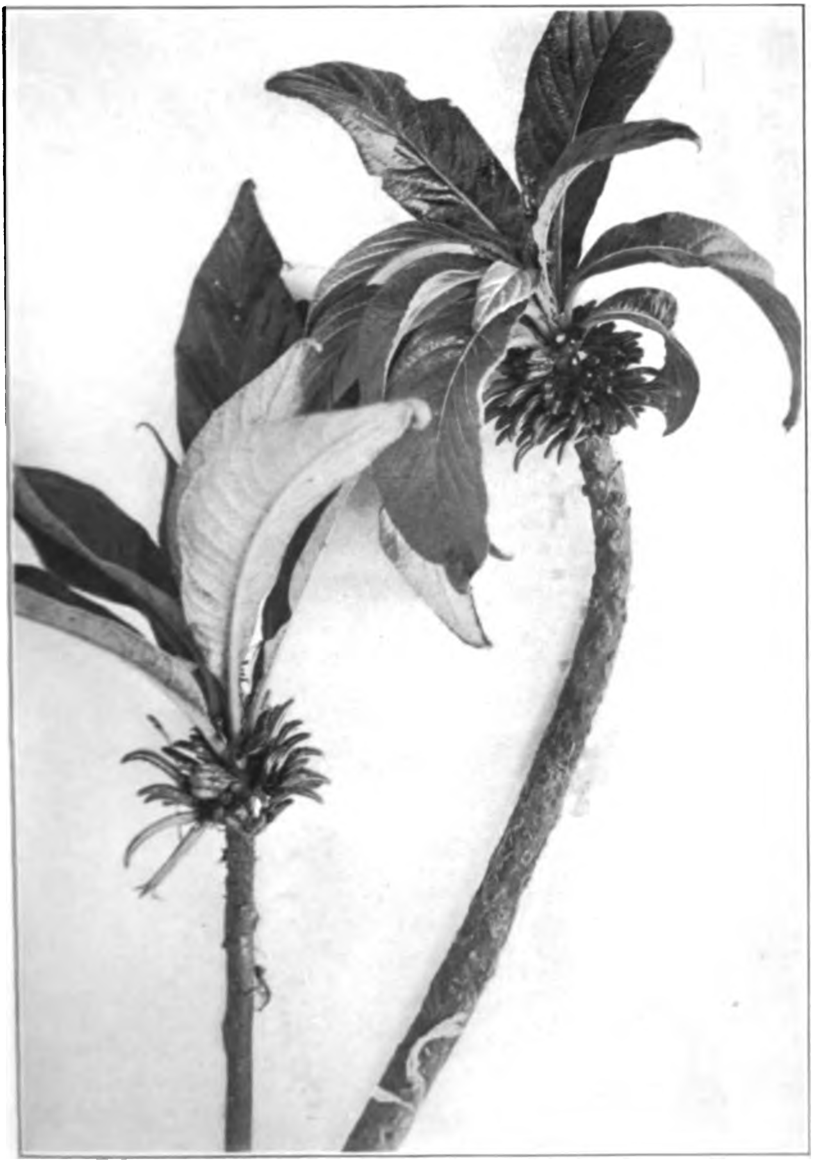

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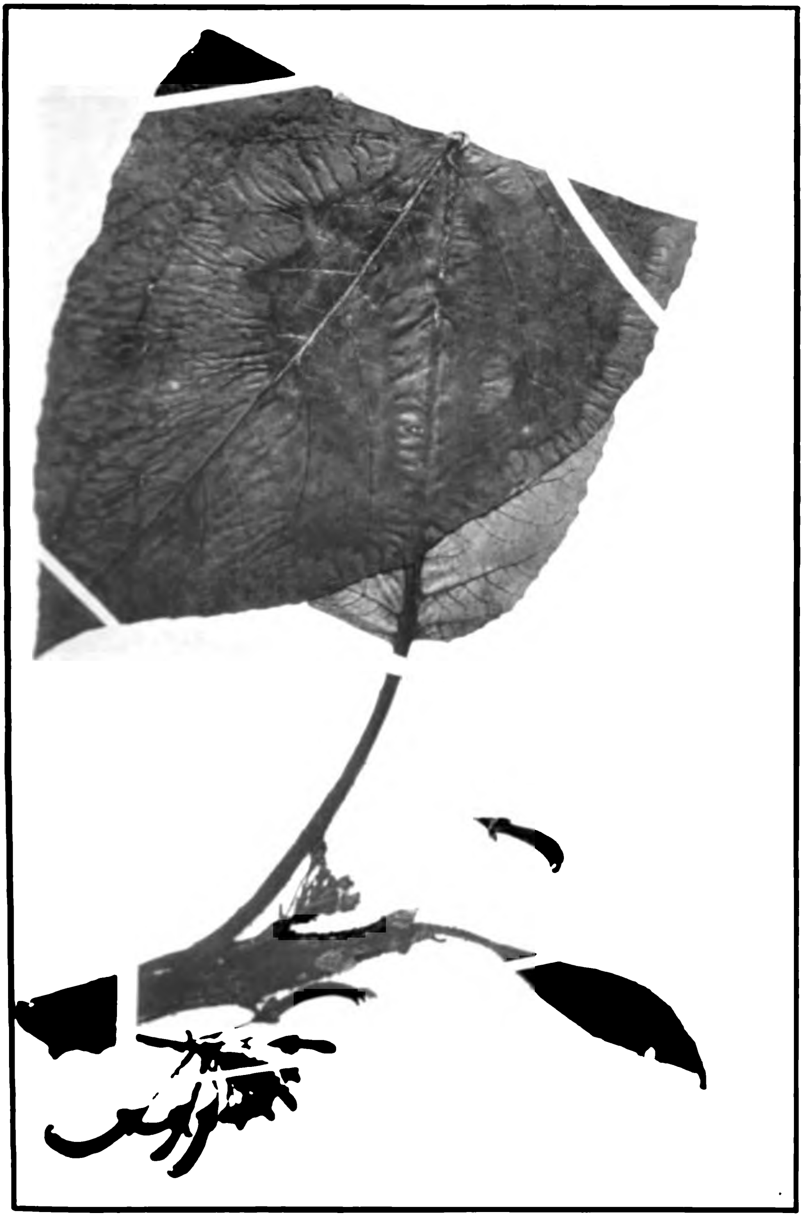

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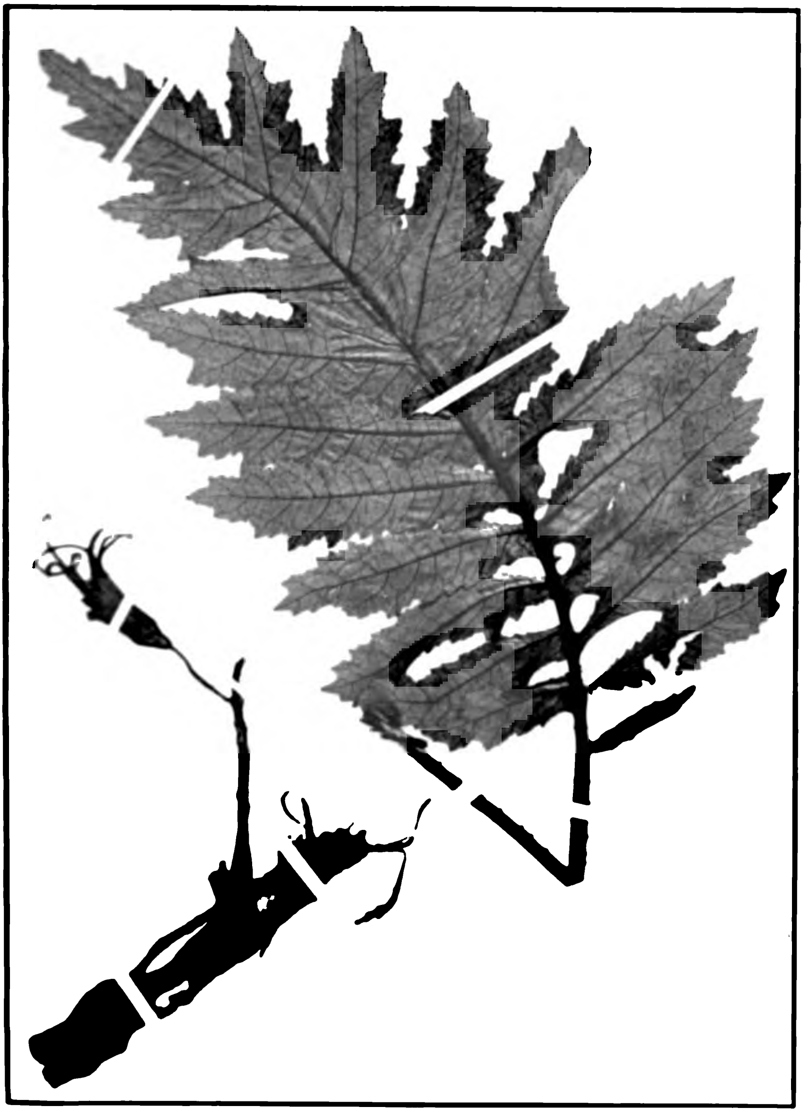

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Vol. 44 No. 6.

BULLETIN

OF THE

TORREY BOTANICAL CLUB

JUNE, 1917

The relationship between the osmotic concentration of leaf sap and height of leaf insertion in trees

J. ARTHUR HARRIS, ROSS AIKEN GORTNER, AND JOHN V. LAWRENCE

(WITH FOUR DIAGRAMS)

I. INTRODUCTION

The ascent of sap in trees presents a problem of such complexity that no one kind of observation is sufficient for its solution. Final conclusions must be based upon the comparison and correlation of careful measurements of all possible variables.

The rôle to be attributed to the osmotic concentration of the fluids of the leaf cells, like other possible factors in the rise of the transpiration stream, is still subject to marked differences of opinion.

One of the simplest and most direct methods of approaching the problem of the relationship between the concentration of the leaf sap and the movement of the transpiration stream is to determine whether leaves originating at a greater distance from the source of water absorption exhibit a higher osmotic concentration than those inserted nearer the source of intake. The importance of such determinations has been recognized by Ewart, Dixon and Atkins, Hannig and others.

Ewart was one of the first, if not the first, to attempt the determination of the osmotic concentration of the leaf sap at different levels. In 1905 he[*] thought he had demonstrated by plasmolytic methods that the concentration of the leaf sap increases from

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[The BULLETIN for May (44: 229–266. *pl.* *9–16*) was issued May 22, 1917.]

[*] Ewart, A. J. The ascent of water in trees. Phil. Trans. Roy. Soc. Lond. B. 198: 41-86. 1905.

lower to higher levels. Later* he returned to the same problem, only to conclude that the sources of error in the use of the plasmolytic method are so great that it was idle to go farther with the study on the basis of the technique then available. After mentioning certain of the difficulties he says:

> "It is more correct therefore to use the term 'plasmalyzing concentration' for results obtained in this manner, and a series of observations for leaf cells of species of *Acacia*, *Eucalyptus*, and *Orevillea* taken from 1–12 meters high show that the concentration may vary from 2–6 per cent. KNO_3 in one and the same plant, and that the variation between leaves at the same level is at first as great as between leaves at different levels, and that the size of the cell and the age of the leaf appear to influence the plasmolytic concentration more than any other factors apart from food storage and assimilation. Hence this promising line of investigation into the problem of the ascent of sap must be abandoned as inaccurate and misleading."

The only exact published data of which we are aware are those furnished by Dixon and Atkins.†

Dixon in his volume on the Ascent of Sap‡ republishes these data with the same interpretation. Working with untreated leaves§ of *Magnolia acuminata*, *Fraxinus excelsior* and *Vitis Veitchii* they secured seven pairs of determinations, from which they conclude:

> "It here appears that, on the whole, taking the experiments in pairs, the leaves at the lower level contained sap with a lower (sometimes considerably lower) osmotic pressure than that of higher leaves. But the experiments are far from satisfactorily bearing out this view; for it will be noted that the osmotic pressure of the sap from leaves at the same level, but at different times and under different conditions, by no means corresponds in each case, although it is often higher than that of leaves at a lower level. The reverse, however, is sometimes found, as in expt. 6 and 7 where the pressure in the lower is much greater than in the higher leaves."

Dixon and Atkins recognized the fact that a relationship between the concentration of the sap of leaves inserted at different distances from the root system might be due to an adjustment to resistance in the conducting system as well as to the hydrostatic

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[*] Ewart, A. J. The ascent of water in trees, II. Phil. Trans. Roy. Soc. Lond. B. **199**: 341–392. 1906.

[†] Dixon, H. H., & Atkins, W. R. G. On osmotic pressures in plants; and on a thermo-electric method of determining freezing points. Sci. Proc. Roy. Dublin Soc. N. S. **12**: 275–311. 1910. Also in Notes, Bot. Sch. Trin. Coll. Dublin **2**, 1910.

[‡] Dixon, H. H. Transpiration and the ascent of sap in plants. London, 1914.

[§] This work was carried out before the necessity for the preliminary freezing of tissues was discovered by Dixon and Atkins. Possibly some of the inconsistencies in their results are due to this fact.

head. They found a slightly greater depression of the freezing point for sap from the more distantly placed leaves. From determinations on *Ulmus campestris* they conclude, however, that the resistance of the water tracts is not the controlling factor but that variation in osmotic concentration is to be attributed principally to the fluctuations in the sugar content due to differences in illumination.

As a final conclusion they state:

> "Variation in pressure is not defined by the height of the leaves above the ground, nor by the resistance of the conducting tracts supplying the leaves. In each case the osmotic pressure was much greater than the tension of the water-supply could have been."

Thus the studies of Ewart leave the fundamental question of the existence of a differentiation in osmotic concentration associated with height quite unanswered, and the careful measurements by Dixon and Atkins are not adequately numerous for a final answer.

Conclusions have been drawn quite contrary to those resulting from the masses of data to be presented below. Thus Hannig* in the introduction to his study of osmotic concentration in root and leaf concludes that the work of Ewart and of Dixon and Atkins shows that "die Differenzen in der osmotischen Werten der Blattzellen einer Baumes von der Höhe des Blattansatzes unabhängig sind."

A proposal to investigate the concentration of the sap of leaves inserted at different levels is frequently met by the objection that the leaves at various heights are really subject to distinct environmental conditions (insolation and air movements) and that these external factors will either obscure any relationship, or, on the other hand, if a relationship between height and concentration be actually found, serve to fully explain it.

To us it has seemed that the primary task, the execution of which should precede all others, is to determine whether as a matter of fact there is a relationship between the level of origin of leaves and the properties of their sap. If there is no such interdependence, it is idle to advance theories in explanation of it, as some botanists seem inclined to do. If, however, careful sets of determinations show that a consistent relationship between height at origin and the osmotic concentration of the leaf sap does obtain, then, and only then, will it be worth while to inquire whether this relationship is of the magnitude necessary to overcome the weight due to the hydrostatic head and the resistance due to the conducting tracts, to measure the various environmental factors with a view to correcting for their influence upon sap properties, and to consider what is the most suitable biological interpretation of the observed relationship.

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* Hannig, E. Untersuchungen uber die Verteilung des osmotischen Druckes in der Pflanze in Hinsicht auf die Wasserleitung. Ber. Deutsch. Bot. Ges. **30**: 194-204 1912.

II. MATERIALS AND METHODS

We took our samples* from trees growing both in the open and in the woods. In collecting the samples we tried to secure them from branches exposed, as nearly as possible, to comparable atmospheric conditions. Such trees are not easy to find, however, and until actual instrumentation for light intensity and for the evaporating power of the air is carried out we shall make no claims whatever for freedom from such influences. In a few cases, indeed, we included trees which for some reasons were desirable, but suffered from lack of uniformity of exposure to light and air. Thus the tree of *Quercus Prinus* was higher than the surrounding vegetation, and the lower branches were somewhat more shaded than the upper ones. The leaves of *Betula lutea* collected July 23 from branches 66 feet above the ground were certainly more intensely illuminated than those at 52, 39, 25 or 11 feet.

In collecting samples of leaves, branches were lopped off at the respective heights and samples of the leaves were picked off as quickly as possible and enclosed in large test tubes which were taken to the laboratory for preliminary freezing[*] in order to facilitate the extraction of samples of sap really representative of the whole mass of tissue, as demonstrated by Dixon and Atkins[†] and confirmed by experiments made subsequently by ourselves.[‡] The freezing-point lowering of the expressed sap, cleared by centrifuging at high speed,[§] was determined by the use of a mercury thermometer graduated in hundredths of degrees in divisions sufficiently large to permit of estimation to thousandths of degrees. The freezing of the sap sample was effected by bubbling a dried air current through carbon bisulphide or ether in a Dewar bulb.

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* In undertaking these studies, we were concerned primarily with securing samples of leaves originating at different levels above the ground. We neglected, therefore, any measurement of the length of branch through which the sap would have to pass after leaving the trunk of the tree. Thus it is not possible to discuss in any exact way the possible influence of the resistance of conducting tracts on the magnitude of the concentration of the sap. Any errors due to this source may probably be disregarded in a preliminary study like the present. In a few cases we secured determinations from leaves originating on horizontal branches at different distances from the main trunk, but almost without exception these materials are open to some objection, and we have excluded them.

The table of constants contains the depression of the freezing point in degrees centigrade, Δ, corrected for the influence of undercooling, and the corresponding values of the osmotic pressure, P, from a published table.[‖]

Specific conductivity at 30° C., κ, was determined in a Freas conductivity cell by means of the ordinary Wheatstone bridge of the physiological laboratory. The cell was standardized with $N/10$ KCl, considered as having a specific conductivity of 0.01412 at 30°.

Freezing point lowering, Δ, and specific conductivity, κ, are the two directly determined constants. Osmotic concentration or osmotic pressure, P, has been determined from Δ, and included in the table, partly because it is easier for some botanists to think in terms of atmospheres than in those of freezing point lowering, and partly because this is necessary for the purpose of ascertaining whether the increase of osmotic concentration with increase of height of insertion is at the rate which would be expected if this increase were an adjustment on the part of the cells to hydrostatic head and to increased resistance of conducting tracts.

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[*] Gortner, R. A., & Harris, J. Arthur. Notes on the technique of the determination of the depression of the freezing point. Plant World 17: 49–53. 1914.

[†] Dixon, H. H., & Atkins, W. R. G. Osmotic pressures in plants. I. Methods of extracting sap from plant organs. Sci. Proc. Roy. Dublin Soc. N. S. 13: 422–433. 1913. Also in Notes, Bot. Sch. Trin. Coll. Dublin 2: 154–163. 1913.

[‡] Gortner, R. A., Lawrence, J. V., & Harris, J. Arthur. The extraction of sap from plant tissue by pressure. Biochem. Bull. 5: 139–142. 1916.

[§] Some of the saps cannot be perfectly cleared by centrifuging.

[‖] Harris, J. Arthur, & Gortner, R. A. Note on the calculation of the osmotic pressure of expressed vegetable saps from the depression of the freezing point, with a table for the values of P for $\Delta = 0.001° - 2.999°$. Amer. Jour. Bot. 1: 75–78. 1914.

Freezing point lowering furnishes a measure of the concentration in moles and ions of all the solutes, non-electrolytes and non-dissociated and dissociated electrolytes. Specific electrical conductivity furnishes a measure of the concentration of dissociated electrolytes only.

It would be highly important to differentiate the electrolytic and the non-electrolytic elements in the solutes to which the whole of the concentration in moles and ions is due. Such differentiation presents, however, in the case of a mixed solution of non-electrolytes and of electrolytes composed of inorganic salts and of weakly dissociable organic salts and acids, a problem of great difficulty. We have therefore contented ourselves with the calculation of the ratio κ/Δ, which is useful although obviously only a substitute for more refined analysis.

Before proceeding to the analysis of the results, a word should be said concerning the trustworthiness of the constants.

There are two sources of error: the probable errors of random sampling in the collection of the leaves and the technical errors in the extraction of sap and in the determination of the constants. The determination of the actual magnitude of these errors presents a problem of considerable difficulty, and we are not in a position to say exactly how large they may be. It is quite clear from the consistency of our results that they are not so great as to obscure the general law, the existence or the non-existence of which we have been seeking to demonstrate.

We do not, however, lay emphasis upon any single constant or difference, and we do not attempt to explain individual inconsistencies. In the rather onerous task of collecting material for and carrying out the determination of 72 freezing points and 66 conductivities, it is highly improbable that we should have been able to avoid entirely probable errors of random sampling in the collection of the tissues and errors of laboratory technique at least as great and sometimes greater than the actual differences of the kind which we have been seeking to demonstrate, if existent.

Thus, even if osmotic concentration increases with height of insertion, one should expect to find a negative relationship indicated by actual measurements occasionally, just as in other instances the increase indicated by the constants would be higher than the true value.*

III. PRESENTATION AND ANALYSIS OF DATA

Altogether 26 sets of determinations were made, covering 12 species of trees. All collections were made in the immediate neighborhood of the Station for Experimental Evolution. The results are given in the accompanying tabular statement.

Here are given the approximate actual heights above the ground of the samples of leaves taken, designated by letters *A*, *B*, *C*, · · · from the highest to the lowest, the depression of the freezing point, Δ, and the osmotic concentration or pressure in atmospheres, *P*, specific electrical conductivities, κ, multiplied by 10^6 and $\kappa \Delta \times 10^6$ of the expressed leaf sap.

These results in terms of osmotic concentration, *P*, are represented in DIAGRAMS 1 and 2, which are self-explanatory.

A cursory examination of the protocol or a glance at the diagrams shows that almost without exception the osmotic concentration is higher in samples taken at the higher levels.

As a means of more exact comparison we have determined the difference in these values for every possible pair of levels, i. e., 1 $2n(n - 1)$ sets of differences for each tree, where n is the number of levels from which samples were taken. These differences are taken (constant for higher level) less (constant for lower level).

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* A particular case in point is that of two determinations based on a tree of *Populus balsamifera*. A first pair of collections made on August 25, indicated that the leaves taken from the 6-foot level contained sap which froze at 0.042° lower than that of leaves from the 25-foot level. A repetition of the collections on August 28 indicated that the sap of the leaves from the 22-foot level froze 0.105° higher – i. e., had 1.26 atmospheres higher osmotic pressure—than those at the 6-foot level.

Note that if these two determinations be averaged, they indicate a higher osmotic concentration for the samples taken at the higher level. Since, however, the two are not consistent we have omitted both. Possibly this tree should not have been used at all since the collections from the lower branches were made from the ends of long branches at a considerable distance from the main trunk. Thus if the resistance of the conducting tracts be a factor of importance it would tend to minimize the difference between the two determinations.

† In two of the determinations based on *Juglans* and in two or more of those based on *Robinia*, collections were made from the same trees in 1914 and 1915. Otherwise all are based on different individuals.

Sample	Height	Δ	P	$\kappa \times 10^5$	$\kappa/\Delta \times 10^5$
***Acer rubrum* L. JUNE 10, 1915**					
A	47	1.385	16.66	863	623
B	27	1.359	16.35	911	671
C	12	1.334	16.05	938	703
***Acer rubrum* L. AUGUST 25, 1915**					
A	50	1.210	14.56	896	741
B	38	1.131	13.61	938	830
C	10	1.084	13.04	834	770
***Acer rubrum* L. AUGUST 25, 1915**					
A	43	1.046	12.59	852	815
B	13	.992	11.94	915	922
***Betula lenta* L. AUGUST 1, 1915**					
A	29	1.518	18.25	1,056	696
B	12	1.411	16.97	1,160	822
***Betula lenta* L. AUGUST 23, 1915**					
A	40	1.046	12.59	—	—
B	17	.933	11.23	—	—
***Betula lenta* L. AUGUST 23, 1915**					
A	46	1.182	14.22	—	—
B	13	1.090	13.12	—	—
***Betula lutea* Michx. JULY 23, 1914**					
A	66	1.293	15.55	1,160	897
B	52	1.331	16.01	1,027	772
C	39	1.257	15.12	1,110	883
D	25	1.173	14.11	1,083	923
E	11	1.050	12.63	990	942
***Fagus grandifolia* Ehrh. AUGUST 20, 1915**					
A	64	1.824	21.92	—	—
B	19	1.441	17.33	—	—
***Fagus grandifolia* Ehrh. AUGUST 25, 1915**					
A	43	1.493	17.95	1,278	856
B	15	1.402	16.86	1,252	893
***Juglans cinerea* L. JUNE 18, 1914**					
A	52	1.522	18.31	1,046	687
B	44	1.525	18.33	1,114	731
C	38	1.429	17.18	1,218	852
D	32	1.513	18.19	1,174	777
E	21	1.484	17.85	1,197	807
F	8	1.398	16.81	1,332	954

Sample	Height	Δ	P	$\kappa \times 10^6$	$\kappa/\Delta \times 10^6$
		Juglans cinerea L. JUNE 4, 1915			
A	41	1.209	14.54	1,208	999
B	30	1.137	13.68	1,232	1,084
C	17	1.131	13.61	1,213	1,072
		Juglans cinerea L. JUNE 8, 1915			
A	45	1.049	12.62	1,435	1,368
B	24	1.015	12.21	1,252	1,234
		Gleditschia triacanthos L. AUGUST 25, 1915			
A	46	1.419	17.07	927	653
B	15	1.285	15.46	938	730
		Platanus orientalis L. AUGUST 28, 1915			
A	66	1.353	16.27	1,458	1,078
B	45	1.267	15.24	1,627	1,284
C	21	1.127	13.56	1,588	1,409
		Quercus coccinea Wang. JUNE 30, 1914*			
A	56	1.592	19.14	981	617
B	33	1.383	16.63	848	613
		Quercus palustris L. JUNE 16, 1914			
A	33	1.932	23.22	903	467
B	23	1.728	20.77	1,002	580
C	9	1.681	20.21	1,057	629
		Quercus Prinus L. JUNE 16, 1914			
A	47	1.683	20.23	1,123	667
B	36	1.670	20.08	1,283	768
C	30	1.640	19.72	1,314	801
D	19	1.628	19.57	1,288	791
		Robinia Pseudacacia L. JUNE 9, 1914			
A	45	1.050	12.63	1,536	1,463
B	12	.902	10.86	1,458	1,616
		Robinia Pseudacacia L. JUNE 9, 1914			
A	45	.969	11.66	1,232	1,272
B	36	.932	11.22	1,267	1,360
C	24	.915	11.01	1,362	1,488
		Robinia Pseudacacia L. JUNE 12, 1914			
A	51	1.034	12.44	1,277	1,236
B	39	.920	11.07	1,181	1,285
C	29	.903	10.87	1,217	1,348
D	9	.887	10.68	1,340	1,511

* In the cases of *Quercus coccinea* of June 30, samples taken at 61 and at 50 feet proved insufficient for a determination of freezing point lowering and have been combined to form a single sample arbitrarily placed at 56 feet.

Sample	Height	Δ	P	$\kappa \times 10^6$	$\kappa/\Delta \times 10^6$
Robinia Pseudacacia L. JUNE 18, 1914					
A.........	41	1.158	13.93	1,512	1,306
B.........	18	1.045	12.57	1,589	1,521
Robinia Pseudacacia L. JUNE 14, 1915					
A.........	40	1.189	14.30	1,379	1,159
B.........	28	1.126	13.55	1,407	1,249
C.........	14	1.017	12.24	1,213	1,193
Robinia Pseudacacia L. JUNE 8, 1915					
A.........	30	.876	10.54	1,061	1,212
B.........	13	.817	9.84	1,390	1,701
Robinia Pseudacacia L. JULY 30, 1915					
A.........	37	1.009	12.14	1,390	1,377
B.........	25	.960	11.55	1,424	1,483
C.........	8	.998	12.01	1,298	1,301
Salix sp. JUNE 8, 1915					
A.........	25	1.029	12.38	1,605	1,560
B.........	10	1.024	12.32	1,599	1,562
Salix sp. JUNE 8, 1915					
A.........	33	1.180	14.20	1,567	1,328
B.........	12	1.171	14.09	1,574	1,344

Thus the signs are positive when osmotic concentration increases with height of insertion.

For example, in the case of *Acer rubrum* of June 10 the differences are:

Heights	$L - L_0$	Δ	P	$\kappa \times 10^6$	$\kappa/\Delta \times 10^6$
$A - B$.....	20	0.026	0.31	− 48	− 48
$A - C$.....	35	0.051	0.61	− 75	− 80
$B - C$.....	15	0.025	0.30	− 27	− 32

It is quite unnecessary to burden these pages with the actual differences, which have been represented graphically in the diagrams. Summarizing the results we note first of all that in 73 of the 78 comparisons which may be made, the sample of tissue collected at the higher level shows a greater concentration than does the one taken at the lower level. More satisfactory evidence of an increase in the concentration of the leaf sap with increase in height of insertion could hardly be desired!

On the assumption of the adjustment of the leaf cells to an increased load—an assumption which we are not at this moment either urging or combating—the increase in osmotic concentration of the sap of the tissues collected at a higher level, L, over that of tissues collected at a lower level, L_0, should be proportional to the combined weight of two factors: (a) the hydrostatic head,

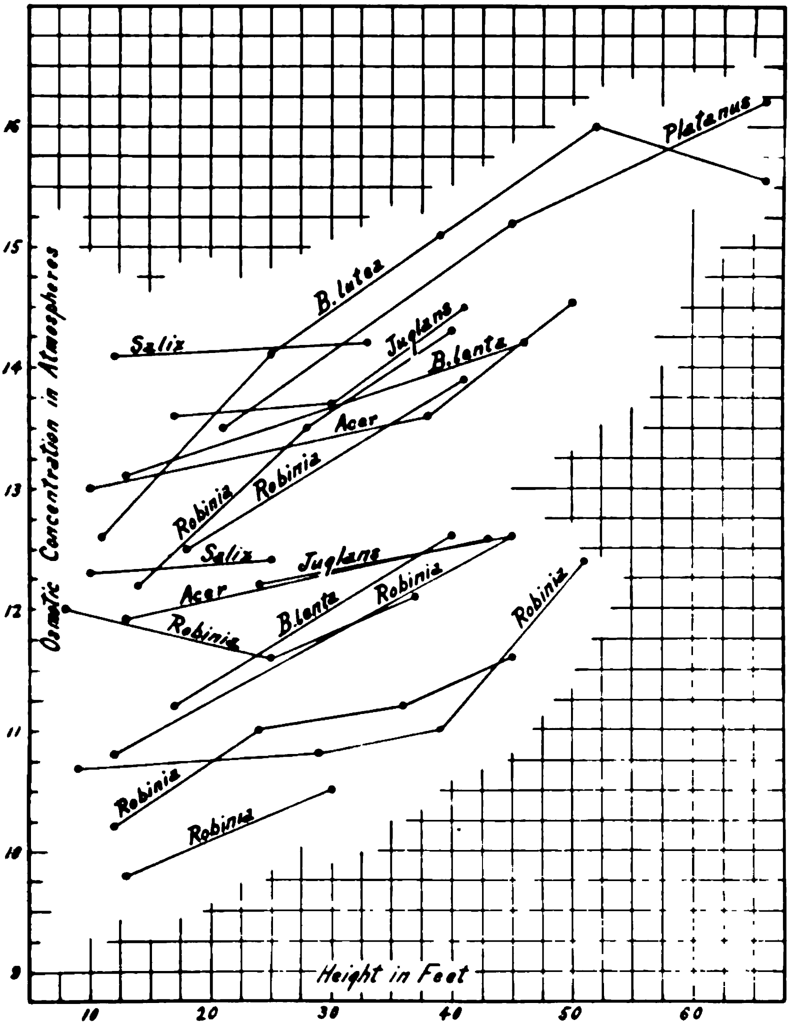

DIAGRAM I

and (*b*) the resistance due to the passage of the column of water of length $L - L_0$ through the conducting tracts.

Since $L - L_0$ is measured in feet, both of these values should be expressed in heights of water column in the same units. Thus the increase in atmospheres pressure due to hydrostatic head, H, should be given by

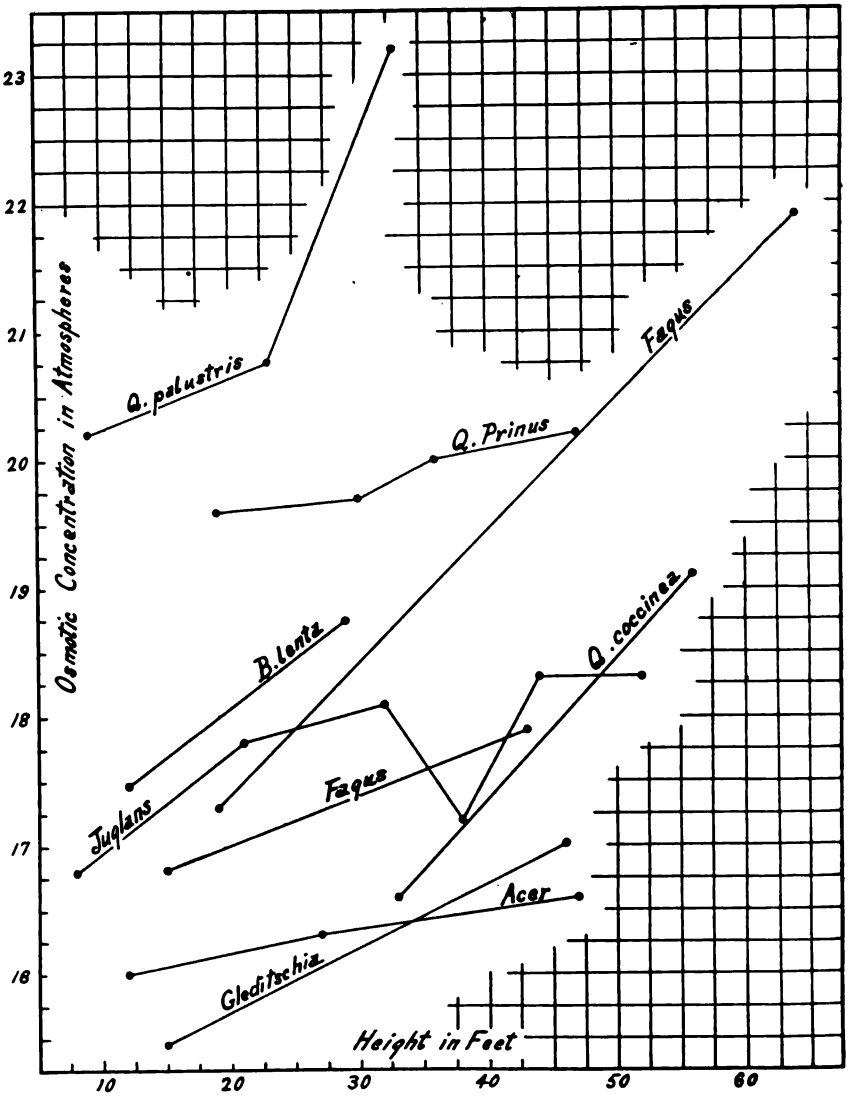

DIAGRAM 2

$$P - P_0 = H,$$

where

$$H = (L - L_0)/34,$$

where except for differences due to the elevation above sea level at which collections are made, H is invariable.

The resistance of the conducting tracts may be most conveniently expressed in terms of the ratio between (1) height of a column of water, R', which is required to force water through a horizontal stem of length $L - L_0$ at the rate of the transpiration stream, and (2) the height of a column of water which is the equivalent of one atmosphere pressure, i. e., $R = R'/34$.

Possibly R, the constant for the resistance of the conducting tracts, may differ from species to species. However this may be, workers who have attempted to determine the value of this constant have come to widely divergent conclusions.

Dixon devotes Chapter VI of his book on Transpiration and the Ascent of Sap to the criticism of the experimental data on the resistance offered by the wood to the movement of the transpiration stream. He concludes:

> "It appears that water may be moved through a stem in a horizontal position with the velocity of the transpiration current if urged by a head equal to the length of the stem. To raise water in a vertical stem at the same velocity, evidently twice the head will be required. Consequently when the force is applied as tension at the upper end, the greatest stress the water need be subjected to is double the height of the moving column."

Now while we may assume that

$$P - P_0 = H + R$$

represents approximately the two most important factors determining any adjustment (if such adjustment really exists) of the cells to increased load, it is quite clear that the equation may not be so simple. Other factors are probably also involved. For example capillarity may diminish the downward pull due to gravity. Possibly the power of imbibition of the leaf colloids may also play a rôle similar to that of the osmotic concentration of the solutes which contribute to the freezing-point lowering.

It is clear that the testing of the experimental results secured in our height studies against this formula is rendered highly questionable by reason of the fact that nothing is definitely known concerning the value of R in the species of trees with which we have worked.

The average ratio of the differences in height of all the possible pairs of samples from the same individual tree to the water-column equivalent of one atmosphere have been computed and found to be

$$\overline{H} = \overline{(L - L_0)/34} = 0.646.$$

Thus if differences in hydrostatic head stood in a causal relation to differences in the osmotic concentration of the leaf sap, and were the only factor of significance, one would expect an average difference of 0.646 atmospheres in the series of differences determined from our observations.

Naturally the resistance of the conducting tracts cannot be neglected. Dixon estimates that at most this is not greater than the hydrostatic head. If twice this value be taken for the sake of obtaining concrete figures the theoretical mean value of the difference in osmotic concentration at two levels would be 1.291.

The observed mean difference in osmotic concentration, P, is almost exactly midway between the two values 0.646 and 2×0.646, i. e., 0.978 as compared with the mid value 0.968.

The closeness of agreement to be expected between observation and theory must depend entirely upon the value assigned to R. Taking $R = H$ the agreement is not good, for the mean value of $P - P_0$ is about 1.00 as compared with the expected 1.30. The value of R which would harmonize hypothesis and observation would be .333 as compared with .646, or about half the hydrostatic head instead of the equivalent of the hydrostatic head considered the maximum value by Dixon. Since determinations of the resistance of the conducting tissues have for the most part been made on cut branches and with methods in which errors are unavoidable, it seems quite possible that half rather than the equivalent of the hydrostatic head may be the true value of the force required to overcome the resistance encountered by water in moving through the conducting tracts of these species at the rate of the transpiration stream.*

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* Capillary rise in the stem and imbibition pressure in the leaf cells would both tend to offset R. Neither of these forces would be included, at least in their entirety, in the direct measurements of R which have been made.

It is perhaps evident from the preceding paragraphs that the four lines of investigation now most needful for a more complete understanding of the relationship between osmotic concentration and level of leaf insertion are: (*a*) more extensive measurements of the resistance opposed to the transpiration stream by the conducting tracts; (*b*) detailed investigations of the properties of the fluids of the transpiration stream at different levels in the trunk throughout the year; (*c*) measurements of the two chief atmospheric environmental factors, evaporating power of air and insolation at different levels; and (*d*) determination of the extent of the rôle played by the imbibition pressure of leaf colloids.

The question of the resistance of the wood system has been touched on above. Further measurements for a great variety of species are needed. The importance for plant physiology in general of the investigation of the composition of the transpiration stream at different levels has been shown by Dixon and Atkins who have provided a method* and have published several series of measurements on trees examined during the winter and vernal season.† It seems rather improbable that such differences as they were able to demonstrate during the period of mobilization of reserve materials should be of great influence at the time at which our determinations were carried out. Nevertheless the subject deserves far more detailed study than Dixon and Atkins have been able to give it in their splendid pioneer work.‡

Differences in the evaporating power of the air and in insolation would (theoretically) influence osmotic pressure by increasing the concentration of solutes in the leaves by evaporation and through differences in the rate of photosynthesis in varying illumination.

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* Dixon, H. H., & Atkins, W. R. G. Osmotic pressures in plants. IV. On the constituents and the concentration of the sap in the conducting tracts, and on the circulation of carbohydrates in plants. Sci. Proc. Roy. Dublin Soc. N. S. 14: 374–392. 1915. Also in Notes, Bot. Sch. Trin. Coll. Dublin 2: 275–293. 1916.

† Dixon, H. H., & Atkins, W. R. G. Osmotic pressures in plants. VI. On the composition of the sap of the conducting tracts of trees at different levels and at different seasons of the year. Sci. Proc. Roy. Dublin Soc. N. S. 15: 51–62. 1916. Also in Notes, Bot. Sch. Trin. Coll. Dublin 2: 335–346. 1916.

‡ Note that Dixon and Atkins find that the concentration of carbohydrates increases from lower to higher levels of the trunk. Possibly this may have some relation to our own findings with regard to the increase of osmotic concentration but the decrease of conductivity, or at least of the ratio of conductivity to freezing point lowering, in leaves inserted at higher levels. See discussion below.

The question of differentiation in atmospheric conditions at various levels in the forest has long received the attention of ecologists. Thus as early as 1888 Schimper* called attention to differences in the epiphytic vegetation of the forest floor and canopy. Shreve in his studies on Jamaican Hymenophyllaceae† and on Jamaican montane rain forest epiphytes in general‡ has emphasized the same point, referring the observed differences to "vertical differences between the climate of the forest floor and its canopy."

Further light is thrown upon the subject by an examination of the specific electrical conductivity of the saps.

While the values of κ measuring the concentration of dissociated electrolytes do not show as great regularity as do those of Δ measuring the concentration of total solutes, the general trend of the relationship between this constant and height of insertion is clearly the reverse of that demonstrated by the freezing-point lowering. Thus in 46 cases the conductivity decreases§ from lower to higher levels as compared with 29 cases in which it increases.|| Thus apparently the saps from higher levels are actually less rich in electrolytes than those from the lower levels.

That samples from higher levels are relatively less rich in electrolytes is splendidly shown by a comparison of the ratios of electrical conductivity to freezing-point lowering, i. e., κ/Δ. These are represented in DIAGRAMS 3 and 4. In all but 13 of the 75 cases the ratio is lower in the saps from the higher levels. Further-

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* Schimper, A. F. W. Die epiphytische Vegetation Amerikas. Bot. Mitt. a. d. Tropen 1, 1888.

† Shreve, F. Studies on Jamaican Hymenophyllaceae. Bot. Gaz. 51: 184–209. 1911.

‡ Shreve, F. A Montane Rain-Forest. Pub. Carn. Inst. Wash. 199: 38–41. 1914.

§ Botanists who are unaccustomed to thinking in physico-chemical terms need only remember that specific electrical conductivity is the reciprocal of the resistance which is inversely proportional to the concentration of ions of electrolytes. Thus a decrease in conductivity indicates a decrease in the concentration of dissociated electrolytes.

|| Confidence in the significance of these differences is increased by the fact that the mean value of the negative differences (i. e., those in which the conductivity at a lower level is greater than that at a higher level) is greater than that of the 29 positive differences.

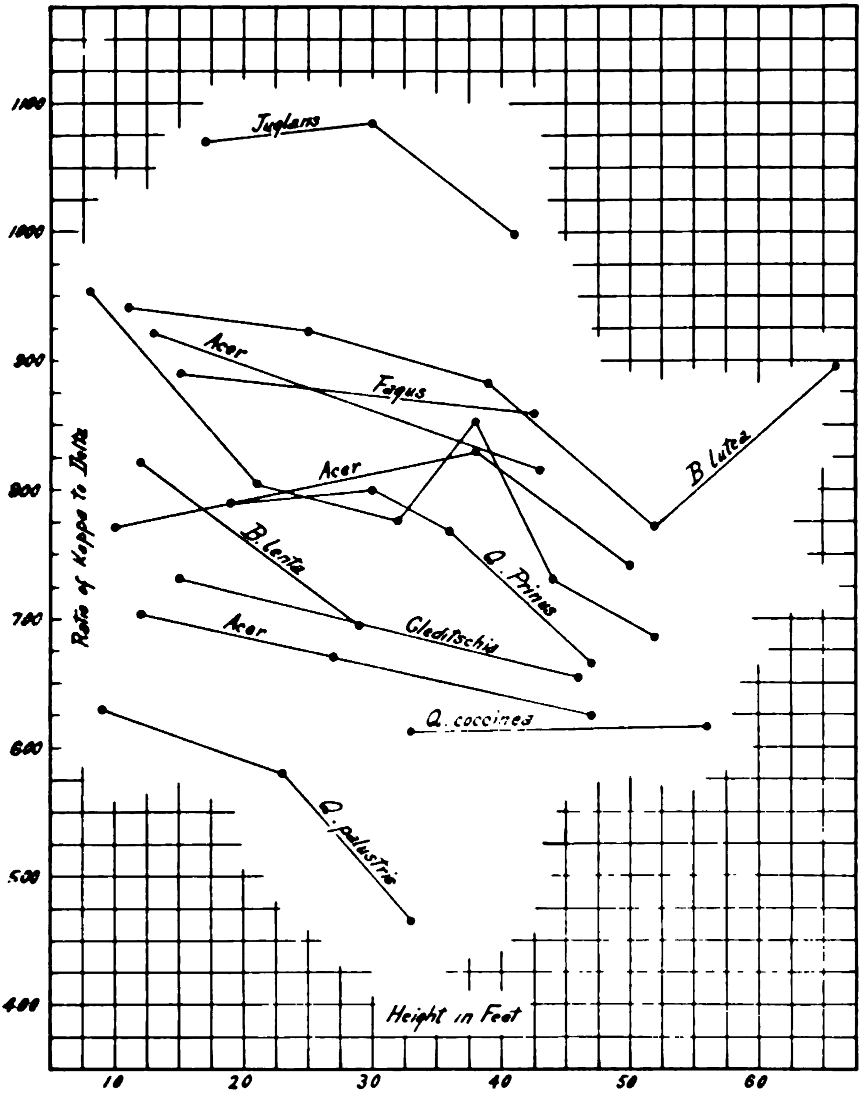

DIAGRAM 3

more, the averages of the negative differences is far higher than. those indicating increase in $\kappa\ \Delta$ with increase in height of insertion. Thus the mean of the positive differences between the values of $(\kappa \Delta) \times 10^4$ for higher and lower levels is only 69.5 as compared

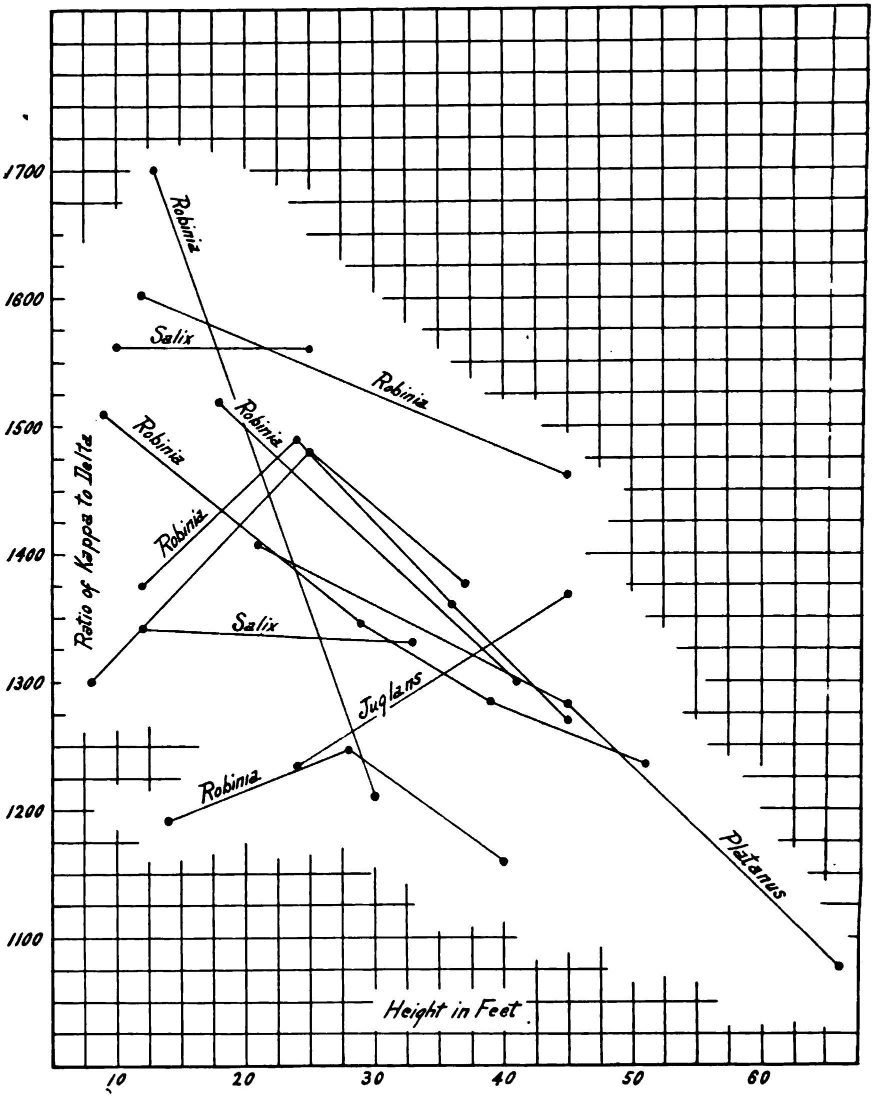

DIAGRAM 4

with a mean of – 112.3 for the negative differences. For all comparisons the mean differences in – 80.7.

Thus our findings apparently indicate that if environmental heterogeneity plays a rôle in the determination of the differences in the physico-chemical constants found, the increased photosynthesis at higher levels is the factor of the greatest importance.

Our own feeling in regard to the matter is that conclusions concerning this question should be deferred until actual measurements of the suggested environmental factors are available.

IV. RECAPITULATION

In the preceding pages we have considered the problem of the relationship between level of insertion and the physico-chemical properties of leaf sap in trees.

Measurements on 26 trees belonging to 12 species show that:

(*a*) The osmotic concentration of the leaf sap as determined by the freezing-point lowering method increases from lower to higher levels. This is true almost without exception.

(*b*) Specific electrical conductivity, κ, shows a tendency to decrease from lower to higher levels. The results are, however, by no means so regular as those for the depression of the freezing point, Δ.

(*c*) The ratio of specific electrical conductivity to freezing-point lowering, $\kappa\ \Delta$, decreases from lower to higher levels. This is true, almost without exception.

The relationship of physico-chemical properties to level of leaf insertion must be due to either internal or environmental factors.

The suggestion is made as a basis for further investigation that if the increase in osmotic concentration with increase in level of insertion be an adjustment on the part of the leaf cell to increased load, the increment in osmotic concentration should be approximately given by

$$P - P_0 = H + R,$$

where P is the osmotic concentration at a higher and P_0 that at a lower level, H is the weight in terms of atmospheres of a column of water $L - L_0$ in height, and R is the resistance, expressed in atmospheres, to the passage of water moving at the rate of the transpiration stream opposed by conducting tracts of the length $L - L_0$, where L and L_0 are the heights of the two levels of leaf insertion.

The ratio

$$\frac{P - P_0}{(L - L_0)\,34},$$

which should equal unity within the limits of experimental error *if increase in osmotic concentration were an adjustment to hydrostatic head alone*, varies widely, with the average value of 1.508. This excess might be expected from the resistance due to the conducting tracts. The closeness of agreement of theory and observation must depend upon the value found for *R*, a value upon which experimenters are not at all in accord.

We must, however, point out that an agreement between the observed increments in osmotic concentration and the theoretical values calculated from the hydrostatic head and the resistance of the conducting elements cannot be taken as proof of an adjustment on the part of the cells to the back pull due to these factors. Such agreement might be purely accidental. Until the possible external factors to which increase in osmotic concentration at higher levels might be due are eliminated by experimental studies, any such agreement should be regarded as a coincidence. Measurements of the extent of differentiation in evaporating power of the air and in the intensity of illumination to which leaves growing at various heights are subjected are urgently needed.

In emphasizing the fact that the results of this study neither substantiate nor disprove the assumption that the back pull due to hydrostatic head and to the resistance of the tracts stand in a causal relation to the increase in osmotic concentration, we must point out that if osmotic concentration of the leaf sap be a factor of importance in the rise of the transpiration stream, the increase in the osmotic concentration with height of insertion may bear a very significant causal relation to the ascent of sap in trees.

The fact that the relative concentration of electrolytes decreases from lower to higher levels would indicate that the differences are due to increased photosynthesis in the upper regions of the tree rather than to the concentration of salts from the soil solution by increased transpiration.

In conclusion, it is perhaps hardly necessary to suggest the desirability of correlating differences already known to be associated with height in trees—for example, heavier fruiting or the development of the so-called shade leaves—with sap properties.

STATION FOR EXPERIMENTAL EVOLUTION,
COLD SPRING HARBOR, NEW YORK

A critical study of certain species of Mucor

ALFRED H. W. POVAH

(WITH PLATES 17–20)

[*Concluded from page 259*]

V. TAXONOMIC

In the preceding experimental part of this work it has been shown that the species of *Mucor*, with but few exceptions, are rather plastic organisms, varying considerably with the external conditions, particularly the substratum. This fact, together with the lack of emphasis as to its importance, especially in questions of taxonomy, has led to a great deal of confusion and often to the description of a single species under several names. In view of this fact it appeared most desirable to attempt a standardization of the cultural requirements and to undertake a detailed study of as many forms as possible under such conditions. Early in the work it was seen that it would be necessary to limit the field of study, and as the genus *Mucor* is composed of so many species which offered difficulty, it was decided to include only this genus in the detailed study. In the aggregate, over one hundred collections (numbering those from which no mucors were isolated) have been made during the last three years. A glance at TABLE I will show the result: eighty-four collections gave mucors, twenty-eight from dung, twenty-two from decaying plant or animal substances, twenty-three from soil, etc. Fourteen genera of the Mucorales, including thirty-seven species, were isolated: *Mucor*, nineteen species; *Absidia*, two species; *Rhizopus*, two species; *Sporodinia*, one species; *Phycomyces*, one species; *Circinella*, one species; *Glomerula*, one species; *Zygorhynchus*, one species; *Helicostylum*, one species; *Thamnidium*, one species; *Pilobolus*, three species; *Chaetocladium*, one species; *Cunninghamella*, one species; and *Syncephalis*, two species.

It will be observed (TABLE I) that sixty-six collections of *Mucor* were obtained, which are referred to nineteen species. Of these, six species are undescribed, viz.: *Mucor abundans*, *M.*

varians, *M. aromaticus*, *M. griseosporus*, *M. coprophilus*, and *M. griseo-lilacinus*.

As has been mentioned before, it was decided to use bread as a standard medium for the comparative study of the species of *Mucor*. A convenient and, at the same time, uniform style of culture was a further desideratum. The tall lipless beakers described in the method of making herbarium preparations proved unsuitable in this case, by reason of their large size, and the impossibility of opening them after they had stood for some time without contaminating the culture. This was doubtless due to the fact that the cotton used to make the (Petri dish) cover tight served as a collector of spore-containing dust. After several arrangements, the following method was evolved, and this has proved successful and easy of manipulation. Two glass capsules, each containing about 1 c.c. of bread (fresh bread, slightly moistened, or dried bread with sufficient water added to form a paste after autoclaving), were placed side by side in a 125 mm. crystallizing dish. This was covered first with a thin layer of cotton batting, and then with a circular glass plate about 12.5 cm. in diameter. These preparations were autoclaved three or four hours at fifteen pounds pressure. All of the descriptions and figures, unless otherwise specified, were made from cultures prepared according to the above-described method. The height in each case was checked by comparison with herbarium cultures in the tall beakers.

The author assumes that anyone attempting to identify a mucor has found some difficulty with the already existing keys, in that it is necessary first of all to determine whether or not the sporangiophores are branched or simple, and if the former, whether racemosely or cymosely branched. To facilitate matters, consideration will first be given to the question of simple and branched sporangiophores. Lendner gives as a parenthetical expression after his unbranched group "exceptionally, when the conditions of nutrition are unfavorable, branches are formed; they are cases of anomaly." This immediately causes trouble, because if branching is found in a species it must be determined whether it is anomalous or not. To give a concrete example, Wehmer (1903) described a mucor under the name *Mucor hiemalis* as "mostly unbranched (seldom with lateral branches)," and this has been placed by Lendner under the unbranched group. Hagem (1908) says that after a study of Wehmer's species he believes that *Mucor hiemalis* has simple sporangiophores only in young cultures, later becoming profusely branched. *M. Mucedo* L., also, has always been classed as a simple form, yet in most descriptions branching is given as occurring rarely. It seems better, therefore, not to follow the traditional separation into branched and unbranched forms. The question of kind or type of branching is even more difficult to determine as both types often occur in the same species (*M. saturninus*). Moreover, different students of the group place the same species under different types of branching. Examples of this disagreement are shown in the case of *M. sphaerosporus*, *M. griseo-cyanus*, and *M. silvaticus*, all of which were described by Hagem. He placed the first two in the *Racemo-Mucor* group and the third in the *Cymo-Mucor* group. Lendner changes all three, placing the first two in the cymose, and the third in the racemose group. From this it is manifest that branching is a poor means of separation of species in a key. For these and other reasons to be given later, the writer has discarded this character in the preparation of the following key which contains the species studied from uniform, standard bread cultures.

KEY TO SPECIES STUDIED

1. Turf 5 cm. tall or over .... 1. *M. proliferus* Schostak.
1. Turf 0.5–5 cm. tall 2
1. Turf less than 0.5 cm. tall 16
2. Spores globose, subglobose to suboval 3
2. Spores not globose to suboval 9
3. Turf some shade of gray 4
3. Turf dark brown 8
4. Turf loose, soon collapsing .... 2. *M. christianiensis* Hagem.
4. Turf dense, remaining erect 5
5. Spores large, shining, 8–13 μ .... 3. *M. lamprosporus* Lendner.
5. Spores small, not exceeding 6 μ 6
6. Columella subglobose to pyriform .... 4. *M. abundans* sp. nov.
6. Columella globose to oval 7
7. Sporangia brownish; circinate sporangiophores near substratum .... 5. *M. circinelloides* Van Tiegh.
7. Sporangia grayish; circinations not present .... 6. *M. corticolus* Hagem.
8. Columella spinescent; chlamydospores rarely in sporangiophores .... 7. *M. plumbeus* Bonorden.
8. Columella smooth; chlamydospores usually in sporangiophores .... 8. *M. sphaerosporus* Hagem.

9. Spores elliptical or cylindrical 10
9. Spores not elliptical or cylindrical 12
10. Culture aromatic; turf ochraceous .... 9. *M. aromaticus* sp. nov.
10. Culture not aromatic; turf gray 11
11. Columella pyriform to panduriform; spores 8–12 × 5–6 μ .... 10. *M. griseosporus* sp. nov.
11. Columella cylindrical to pyriform; spores 9–16 × 5–8 μ .... 11. *M. coprophilus* sp. nov.
12. Turf ivory yellow to olive buff (Ridgway) .... 12. *M. varians* sp. nov.
12. Turf some shade of gray 13
13. Turf loose; columella oval to pyriform .... 13. *M. saturninus* Hagem.
13. Turf dense; columella not oval to pyriform 14
14. Spores not uniform, subreniform, subfusiform .... 14. *M. hiemalis* Wehmer.
14. Spores uniform oval 15
15. Sporangia deep bluish-gray; circinate sporangiophores near substratum .... 15. *M. griseo-cyanus* Hagem.
15. Sporangia dark greenish-gray; circinations not present .... 16. *M. griseo-lilacinus* sp. nov.
16. Turf red; columella smooth .... 17. *M. Ramannianus* Moeller.
16. Turf brown; columella spinescent .... 18. *M. spinescens* Lendner.

DESCRIPTIONS OF SPECIES

1. MUCOR PROLIFERUS Schostak. Ber. Deutsch. Bot. Ges. 14: 260. *pl. 18, f. 1–14.* 1896

Forming on bread a loose, erect, smoke gray (Ridgway) turf, tinged drab, 2–6 cm. tall; *sporangiophores* septate, 23–82 μ in diameter, simple or profusely branched, with long and then usually simple, or short, simple or ramified branches; *sporangia* large (terminal) or small (lateral), 210–349 μ and 31–74 μ in diameter, respectively, encrusted with crystals, small lateral sporangia often deciduous; *sporangium wall* persistent or rupturing (in the case of the small sporangia), or deliquescent (large terminal sporangia), leaving a basal membrane; *columella* free, cylindrical to pyriform (approaching panduriform), 125–150 × 58–90 μ (extremes 70–266 × 43–174 μ), tinged brownish; *spores* elliptical, 8–10 × 4–6 μ in diameter (extremes 6–16 × 4–8 μ), hyaline; *zygospores* globose or somewhat flattened at the ends (diameter with axis through suspensors 17–31 μ less than diameter perpendicular to it), 154–168 × 127–137 μ (extremes 116–182 × 99–154 μ), dark brown, becoming brownish black at maturity, young zygospores with small, round warts, which become large and irregular in mature zygospores, suspensors subequal, heterothallic (single spore cultures produce no zygospores). [PLATE 19, FIGS. 6–10.]

This interesting species was collected only once, on dung. The zygospores, before unknown, were found in the original culture and in cultures made by gross transfers to bread. In order to separate this mucor from other fungi present, single spore cultures were made and only one strain was isolated. The collection dates from the early part of the work (1913); consequently no effort was made to isolate both strains. No. 34.

This mucor exhibits a great difference in height according to the substratum. A maximum height of 68 mm. was obtained on rolled oats; while the following data give some idea of the range of variation: bread and cornmeal, 60 mm.; potato agar, 55 mm.; rice, 40 mm. with no color production; bean agar, 33 mm. On grapefruit it does not exceed 3 mm. It was found to ferment dextrose and to oxidize tyrosin solution.

2. MUCOR CHRISTIANIENSIS Hagem, Ann. Mycol. **8**: 268. *f. 2–3.* 1910

Forming on bread a loose, smoke gray turf (Ridgway), with drab tinge, 1–3.5 cm. tall, soon collapsing; *sporangiophores* 6–16 μ in diameter, sparsely ramified with a few long or short branches ending in a sporangium and with a septum above point of insertion of branch; *sporangia* globose, 50–80 μ (extremes 43–121 μ) in diameter, pale brown, transparent with the spores showing through; *sporangium wall* rupturing, leaving a usually large, or small basal membrane; *columella* free or slightly adnate, oval to pyriform, 20–82 × 16–62 μ, pale brown; *spores* subglobose to suboval, 6–10 × 5–8 μ or 5–9 μ in diameter (extremes 4–12 × 3–10 μ); *chlamydospores* numerous in the sporangiophores, oval or barrel-shaped when young, globose at maturity, 16–23 μ in diameter; *zygospores* not found (presumably heterothallic).

This species was collected four times; twice from soil in potting bench and bed of different greenhouses, once on fallen leaf (by Mr. E. Levin), and once on Brazil nut. Nos. 48, 54, 59, and 77. It is related, as Hagem (1910) has pointed out, to *Mucor racemosus* Fresen., but differs principally in the fact that the chlamydospores become spherical at maturity, while in *M. racemosus* they remain barrel-shaped.

Mucor christianiensis varies but little in height on the different substrata used: on rice it is 5–10 mm. high; on bread, 4–8 mm.; and on grapefruit, 3–10 mm. The species was found to ferment dextrose but did not oxidize tyrosin. Moreover, it does not form any yellow color on rice.

3. MUCOR LAMPROSPORUS Lendner, Bull. Herb. Boissier II. **8**: 78. 1908; Les Mucorinées de la Suisse, 92. Berne, 1908

Forming on bread an erect, dense, pale smoke gray (Ridgway) turf, 1.5–3 cm. tall; *sporangiophores* 10–23 μ in diameter, ramifying with a few long branches, or with very short, circinate branches, ending in a sporangium; *sporangia* globose, terminal 62–82 μ in diameter, lateral 33–43 μ; *sporangium wall* of large sporangia rapidly deliquescent (glycerine mount necessary to obtain sporangial measurements), of small sporangia persistent or dissolving, leaving a slight basal membrane; *columella* globose to oval, free, 16–51 × 18–43 μ; *spores* globose, shining, large, 8–13 μ in diameter; *zygospores* not found (presumably heterothallic).

A single collection of this species, easily recognized by the large shining spores, was obtained from an oak root, found by Mr. H. Andrews, brought into the Cryptogamic Laboratory and placed in a moist chamber for study of mycorhiza. No. 35. It is interesting to note, in this connection, that the closely-related species *Mucor sphaerosporus* Hagem was obtained from mycorhiza of *Pinus montana* by Professor Gran in Norway.

On rice this species grows 25 mm. high and on grapefruit 17 mm. It ferments dextrose, but does not oxidize tyrosin.

4. **Mucor abundans** sp. nov.

Forming on bread a dense, erect, smoke gray turf (Ridgway), tinged drab, 1.5–3.5 cm. tall; *sporangiophores* 8–23 μ in diameter, at first simple, later with one to three lateral branches which are in turn branched once or twice (exceptionally five times), with branches always terminating in a sporangium, and with a septum above point of insertion of branch; *sporangia* globose or subglobose, smooth or incrusted with very delicate crystals, 56–78 μ in diameter (extremes 39–98 μ), at first yellowish, becoming dark gray with a greenish tinge at maturity; *sporangium wall* deliquescent, leaving a basal membrane; *columella* subglobose to pyriform, free or slightly adnate, 31–40 × 25–35 μ (extremes 21–66 × 20–55 μ), hyaline or tinged gray; *spores* variable, globose to short elliptical, 3–5 μ in diameter or 4–5.5 × 3–4.5 μ (a few 8 × 6 μ); *chlamydospores* and yellowish globules in submerged mycelium; *zygospores* not found (presumably heterothallic). [PLATE 17, FIGS. 1–6.]

This species was found to be very common, no less than eleven collections having been made from the following sources: three times from horse dung, twice from sandy tilled soil, three times from dung (presumably squirrel), once from decaying tomato, rabbit dung, and dog dung, respectively. Nos. 7, 9, 14, 19, 22, 25, 28, 31, 32, 33, and 60. Nos. 14 and 22 were collected by Messrs. K. Duncan and E. B. Mains, respectively.

Mucor abundans is characterized by the oval to pyriform columella, the variable—globose to short-elliptical—spores, and the color of the turf (smoke gray tinged drab). It is related to *Mucor griseo-lilacinus*, but differs from it in the color of the turf, the oval to pyriform columella, the variable—globose to short elliptical—spores, and the absence of the lilac tinge in the columella and hyphae. It is also related to *M. hiemalis* (sense of Hagem), from which it differs in the shape of the columella and in the shape and size of the spores.

Mucor abundans grows 40 mm. tall on rolled oats, 30 mm. tall on corn meal, 25–35 mm. tall on rice, with or without the formation of buff to yellow line around edges of surface of rice, and 9–18 mm. tall on grapefruit. It ferments dextrose, but does not oxidize tyrosin.

5. Mucor circinelloides Van Tiegh. Ann. Sci. Nat. Bot. VI. 1: 94. 1875

Forming on bread a dense, pale smoke gray (Ridgway) turf, 1–3 cm. tall; *sporangiophores* 8–16 μ in diameter, tall and short, tall forming a turf 2–3 cm. tall, and short attaining only 1–2 mm. in height, *tall sporangiophores* with long or short branches, *short sporangiophores* more profusely branched with short and often circinate branches, always terminating in a sporangium and with a septum above the point of insertion of branch; *sporangia* globose, of tall sporangiophores, 50–70 μ in diameter (extremes 43–80 μ), of dwarf sporangiophores, 14–35 μ in diameter, at first yellowish, becoming brownish gray at maturity; *sporangium wall* deliquescent in sporangia borne on tall sporangiophores, rupturing or persistent in sporangia of dwarf circinate sporangiophores, leaving a basal membrane; *columella* free, globose to oval, 31–43 × 31–39 μ (extremes 20–51 × 18–43 μ), tinged grayish; *spores* uniform, subglobose to oval, 3–5 × 3–4 μ or 3–5 μ in diameter (extremes 8 × 6–8 μ in diameter); *chlamydospores* and oidia in and on substratum, chlamydospores 20 × 12 μ; *zygospores* not found (species heterothallic).

This species is characterized by the tall and short (often circinate) sporangiophores, the subglobose to oval columella, and the uniform—subglobose to oval—spores, measuring 3–5 × 3–4 μ or 3–5 μ in diameter. It is related to *M. griseo-cyanus* Hagem, from which it differs in the color of the turf, color of the sporangia, and the spores. It is also related to *M. abundans* but differs from it in the color of the turf, circinate ramifications, shape of columella, and the spores. In *Mucor circinelloides* the spores are uniform, subglobose to oval, while in *M. abundans* they are variable, globose to short elliptical, also slightly larger.

Mucor circinelloides was collected six times from soil, four times from tilled soil, once from greenhouse (potting bench), and once from soil in cold frame. Nos. 38, 39, 42, 43, 45, and 56.

This species is 15–35 mm. tall on rice, without color production or with a pale pinkish (or ochraceous) buff (Ridgway) line around the edges of the top of the substratum. On grapefruit it is 2–17 mm. tall. It ferments dextrose but does not oxidize tyrosin solution.

6. MUCOR CORTICOLUS Hagem, Ann. Mycol. 8: 277. *f. 8.* 1910

Forming on bread a dense, pale smoke gray to smoke gray (Ridgway) turf, 0.5–2 cm. tall; *sporangiophores* 6–16 μ in diameter, profusely branched with long often ramified branches, terminating in a sporangium and with a septum above point of insertion of branch; *sporangia* encrusted with delicate crystals, globose, 51–94 μ in diameter, dark gray; *sporangium wall* deliquescent, leaving a large or small basal membrane; *columella* free or slightly adnate, mostly oval (a few subglobose), 31–62 × 27–32 μ (extremes 16–62 × 14–51 μ), tinged gray; *spores* subglobose to suboval, 3.5–5 × 3–3.5 μ or 4–5 μ in diameter (extremes 8 × 6 μ or 6–7 μ in diameter); *zygospores* not found (species presumably heterothallic).

A single isolation of this species was obtained from soil (just beneath the surface) in a corn field. No. 57. This species, which is related to *M. silvaticus* Hagem, is characterized by the fact that the lateral branches are usually shorter than the long, often bending main axis; by the usually oval columella; and by the different-shaped and often larger spores.

Mucor corticolus forms a drab gray (Ridgway) turf, 2 cm. tall on rice with the production of a pinkish buff line around the edges of the surface of the rice. It ferments dextrose but does not oxidize tyrosin.

7. MUCOR PLUMBEUS Bonorden (sense of Lendner), Abh. Naturf. Ges. Halle 8: 109. *pl. 1, f. 20.* 1864

Forming on bread a dense, fuscous (Ridgway) turf, 0.1–1 cm. tall; ***sporangiophores*** 10–16 μ in diameter, profusely branched with branches ending in a sporangium and with a septum above point of insertion of branch, also septate at irregular intervals in the sporangiophores; ***sporangia*** globose, 60–80 μ in diameter (extremes 35–117 μ), brownish black, encrusted with crystals or smooth; ***sporangium wall*** deliquescent, leaving a basal membrane; ***columella*** free, oval, pyriform, elongated, or conical, smooth or furnished with one to twelve spines at the apex, 30–60 × 16–32 μ (extremes 16–74 × 12–59 μ), dark brown; ***spores*** globose, 6–9 μ in diameter (extremes 5–13 μ), also a few elliptical and irregular-shaped spores, 23 × 18, 16 × 12 μ, dark brown, punctate; ***zygospores*** not found (species heterothallic).

This species was obtained four times: twice as contamination in cultures; from *Sphagnum* with germinating seeds; and from a decayed Brazil nut. Nos. 47, 51, 61, and 78. The species is quite variable, as a comparison of the descriptions given by Fischer and Lendner will show. Moreover, there are transitional forms between it and the closely related species, *M. spinescens* Lendner. On potato agar, rolled oats, and bread, *M. plumbeus* reaches a height of 10 mm., on rice, 7–8 mm., on cornmeal, 5 mm. and on grapefruit, 4–5 mm. There is no color production on rice. It ferments dextrose and oxidizes tyrosin, but more slowly than *M. coprophilus* and *M. griseosporus*.

8. MUCOR SPHAEROSPORUS Hagem, Vid.-Selsk. Skr. M.-N. Kl. Christiania 1907^7: *22. f. 4.* 1908

Forming on bread a dense, 2 mm. high, and a sparse, 1 cm. high, hair brown (Ridgway) turf; ***sporangiophores*** 6–18 μ in diameter, typically branched, with one long branch (in turn profusely ramified), or several short, simple branches, in either case with branches terminating in a sporangium and with a septum above the point of insertion of a branch; ***sporangia*** globose, 78–86 μ in diameter (extremes 59–98 μ), with spores shining through, brown; ***sporangium wall*** deliquescent, leaving a basal membrane; ***columella*** free or slightly adnate, subglobose to pyriform, 39–59 × 35–47 μ (extremes 23–70 × 21–59 μ), tinged brown; ***spores*** uniformly globose, 5–8 μ in diameter (extremes 4–10 μ), yellowish; ***chlamydospores*** in sporangiophores, globular, with central oil globule; ***zygospores*** not found (presumably heterothallic).

This species was obtained twice, from decayed leaf and as a contamination in a culture. Both of these the writer received from Mr. E. Levin. Nos. 49 and 50. It belongs to the *M. racemosus* group of mucors but can readily be distinguished from the above-mentioned species by the color of the turf, which is nearest to that of *M. plumbeus*, although it is slightly lighter. The branching in *M. sphaerosporus* is much more profuse than in *M. racemosus;* and while the spores are very similar in the two species, the chlamydospores are different. In *M. sphaerosporus* they are globular and have a central oil globule.

This species forms a hair brown (Ridgway) turf, 1–2 cm. tall on rice, without any yellowish coloration near surface of substratum; on grapefruit a 7–8 mm. tall, gray turf is produced. Dextrose is fermented but tyrosin is not oxidized by this species.

9. **Mucor aromaticus** sp. nov.

Forming on bread a loose, yellow ochre to ochraceous orange (Ridgway) turf, 2–3 cm. tall; *sporangiophores* 20–50 µ in diameter, typically unbranched or with one to three lateral branches always terminating in a sporangium; *sporangia* globose, 100–160 µ in diameter, encrusted with small crystals, more or less transparent, showing the spores within; *sporangium wall* deliquescent, without or with basal membrane; *columella* free, subglobose to oval, approaching pyriform, 51–121 × 43–105 µ, with or without protoplasmic contents, hyaline; *spores* uniform elliptical, 18–20 × 10 µ (extremes 15–35 × 7–14 µ), a few oval, also approaching spherical; *culture* strongly aromatic, with odor somewhat like camphor and celluloid; *zygospores* not found (species presumably heterothallic). [PLATE 17, FIGS. 7–11.]

This species is characterized by its ochraceous color and its odor. Its origin was dung (squirrel?), and the writer is indebted to Professor J. B. Pollock, who collected it. No. 24.

Mucor aromaticus varies with the substratum as may be seen from the following data. On potato agar it grows 32 mm. tall; on bean agar, 20 mm.; on apple agar, 11 mm.; on rolled oats, 30 mm.; on cornmeal, 20 mm.; on starch paste, 20 mm.; and on rice, 20–30 mm. (often coloring the whole substratum yellow). It ferments dextrose (slight amount of alcohol found on second distillation), but does not oxidize tyrosin. Cultures on the following substrata were strongly aromatic: rolled oats, cornmeal, beef gelatin, potato agar, dextrin gelatin, and rice. On starch paste and apple agar, however, the odor was slight.

10. **Mucor griseosporus** sp. nov.

Forming on bread a loose, erect, light grayish olive (Ridgway) turf, tinged brown, 3–4 cm. tall; *sporangiophores* with brownish membrane, 20–70 μ in diameter, typically unbranched, or with one or two short lateral branches terminating in small sporangia, becoming septate in old cultures; *sporangia* globose, terminal 244–302 μ in diameter, encrusted with crystals, lateral up to 98 μ in diameter, at first yellowish becoming dark gray at maturity; *sporangium wall* deliquescent (except in small sporangia) leaving a basal membrane; *columella* free, pyriform, pyriform broadened at the base, or panduriform, 115–242 × 88–165 μ usually with yellowish to pale orange contents; *spores* uniform, elliptical 8–12 × 5–6 μ (extremes 8–15 × 5–8 μ), clear gray, in mass almost black, agglutinate; *zygospores* not found (presumably heterothallic). [PLATE 18, FIGS. 1–5.]

This species is characterized by its simple or slightly branched, septate, sporangiophores; its pyriform columella; and gray, uniformly elliptical spores. It is related to *M. piriformis* Fischer, but differs from it in the fact that the lateral branches terminate in sporangia; in having septate sporangiophores; basal membrane present; and slightly larger, and clear gray spores. Collected a single time on dung. No. 26.

M. griseosporus grows as follows: on rolled oats, 70 mm. tall; on potato agar and cornmeal, 65 mm. tall; on starch paste and rice, 50 mm.; on bread and apple agar, 40 mm.; on bean agar, 27 mm.; and on grapefruit, 21 mm. On rice there is no color production. It ferments dextrose to a slight extent, and oxidizes tyrosin.

11. **Mucor coprophilus** sp. nov.

Forming on bread a loose, light grayish olive (Ridgway) turf, 2–2.5 cm. tall; *sporangiophores* brown, 27–46 μ in diameter, ramifying with long branches, or shorter, simple or ramified, more slender branches (terminating in small often deciduous sporangia 20–62 μ in diameter, with rupturing membrane); *sporangia* (large terminal) globose, encrusted with crystals, 185–235 μ in diameter, whitish at first, becoming almost black at maturity; *sporangium wall* readily deliquescent (except in the case of sporangia on dwarf sporangiophores), leaving a small basal membrane; *columella* free, cylindrical to pyriform, 110–160 × 70–113 μ, brownish, sometimes with orange contents; *spores* narrowly elliptical in larger sporangia, 13–16 × 5–6 μ, broadly elliptical in smaller sporangia, 9–12 × 7–8 μ, grayish; *chlamydospores* rarely in sporangiophores; *zygospores* not found (presumably heterothallic). [PLATE 19, FIGS. 1–5.]

This species is characterized by its varied habit of branching; its small, lateral, often deciduous sporangia, recalling *Mucor lamprosporus;* its cylindrical to pyriform columella; and its variable spores, narrowly elliptical and broadly elliptical in the larger and smaller sporangia respectively. It is related to *Mucor griseosporus*, from which it differs in its slightly lighter colored and shorter turf; more slender and more profusely branched sporangiophores; cylindrical to pyriform columella; and its variable (broadly to narrowly elliptical), larger, non-agglutinate spores. A single collection was obtained of this characteristic species from rabbit dung. No. 73. Ellis & Everhart's North American Fungi *972* is certainly not *Mucor Mucedo* (sporangia and spores too large), and probably ought to be referred to *M. coprophilus*.

This species forms a 30 mm. tall, Saccardo's olive (Ridgway) turf on rice and a 25 mm. tall, brownish gray turf on grapefruit. It produces no color on rice but oxidizes tyrosin and ferments dextrose to a slight extent.

12. **Mucor varians** sp. nov.

Forming on bread a dense, ivory yellow to olive buff (Ridgway) turf, 1–3.5 cm. tall; *sporangiophores* 8–20 μ in diameter, either little or profusely branched, much coiled, twisted or intertwined, forming a dense, tough, cottony turf, with proliferations of hyphae and columellae often present; *sporangia* globose or subglobose, smooth, 60–80 μ in diameter (extremes 43–116 μ), at first yellowish or pale orange, becoming very dark gray, tinged green, at maturity; *sporangium wall* deliquescent, leaving a basal membrane; *columella* free or slightly adnate, very variable in shape, subglobose, hemispherical, flattened hemispherical, oval, cylindrical, elliptical, pyriform, panduriform, cylindro-conical, subconical and conical, large columellae hemispherical to conical, small columellae cylindrical to pyriform and panduriform, 25–50 × 20–45 μ (extremes 18–70 × 12–59 μ), membrane tinged gray, with or without orange contents; *spores* not uniform, oval to subelliptical (few spherical), 4–6 × 3–4 μ (extremes 4–14 × 3–8 μ), 4–8 μ in diameter, bizarre spores not rare, reniform, cruciform, etc.; *zygospores* not found (presumably heterothallic). [PLATE 20, FIGS. 1–6.]

This species was isolated from soil (in hardwoods and tilled) four times; also from stable bedding and manure; from the stem of a decaying apple; and from *Calvatia* sp. (the last-mentioned collected by Dr. E. B. Mains). Nos. 18, 21, 29, 36, 37, 46, and 58.

Mucor varians is characterized by the color of its turf, chamois to deep olive buff (Ridgway) in dried herbarium specimens; by the extremely variable shape of the columella; by its dissimilar spores; and by its habit of growth, i. e., the peculiar intertwining, coiling, and proliferation of the hyphae. This species resembles *Mucor Jansseni* Lend. in the shape of the columella.

Mucor varians forms a light grayish olive to cartridge buff (Ridgway) turf, 25–30 mm. tall on rice, sometimes with the yellowish line at the edge of the surface of the medium. On grapefruit a gray or yellowish gray turf is formed, 8–15 mm. tall (sometimes with a bright orange line around the edge of the surface of the medium). It ferments dextrose but does not oxidize tyrosin.

13. MUCOR SATURNINUS Hagem, Ann. Mycol. **8**: 265. *f. 1.* 1910

Forming on bread a loose, gull gray (Ridgway) turf, 2–2.5 cm. tall; *sporangiophores* of two kinds, tall and short, the former composing the turf, the latter forming patches of dark gray felt (less than 1 mm. thick) on the substratum, *tall sporangiophores* 12–35 µ in diameter, typically unbranched (sometimes with a single short branch ending in a sporangium), *short sporangiophores* simple or branched; *sporangia* globose, 57–156 µ in diameter, at first yellowish, becoming almost black at maturity, finely incrusted with crystals; *sporangium wall* dark gray, deliquescent (in sporangia of tall sporangiophores), rupturing (or persistent in sporangia of short sporangiophores), leaving a large or small basal membrane; *columella* free, tinged grayish, oval to pyriform, 34–107 × 39–80 µ, with or without pale orange contents; *spores* uniformly oval, variable in size, 6–8 × 4–6 µ (extremes 4–12 × 3–7 µ), pale gray in mass; *zygospores* not found (presumably heterothallic).

This species was found on horse dung and on decaying *Collybia dryophila* Bull. Nos. 10 and 68.

Mucor saturninus is characterized by the varying height of the sporangiophores, by the shape of the columella, and by the uniformly oval spores. The color of the turf is also characteristic.

This species forms a 14–20 mm. tall, gray turf on grapefruit and on rice a 10–20 mm. tall, pale smoke gray to smoke gray (Ridgway) turf. It ferments dextrose but does not oxidize tyrosin.

14. MUCOR HIEMALIS Wehmer, Ann. Mycol. 1: 37. *f. 1–9.* 1903

Forming on bread a dense, grayish white (Ridgway) turf tinged tilleul buff, 1–3 cm. tall; *sporangiophores* 16–20 µ in diameter, at first simple or, more often, once or twice (exceptionally up to six times) branched, with a septum immediately above point of insertion of branches, all of which terminate in a sporangium; *sporangia* globose, 60–75 µ in diameter (extremes 30–100 µ), at first yellowish becoming dark gray with a greenish tinge at maturity; *sporangium wall* deliquescent, leaving a basal membrane; *columella* free, globose to subglobose, 30–50 µ in diameter (extremes 20–55 µ), hyaline; *spores* variable in shape and size, subfusiform, subreniform, narrowly oval, subelliptical, 4–8 × 2–4 µ (a few 8–9 × 4–6 µ), hyaline; *zygospores* not found (species heterothallic). [PLATE 20, FIGS. 7–10.]

This species was isolated from various types of soil, from several kinds of dung, and from decaying mushroom. Nos. 4, 5, 6, 13, 72, and 74.

This agrees with Wehmer's description in general although the sporangia and columella are slightly larger, and branching is frequent. Both of these differences may be due to the influence of the substratum, as Wehmer has pointed out the variability of this species. The spores are characteristically variable, reniform being a common shape.

Mucor hiemalis exhibits the following cultural characteristics: on rice it forms a slightly yellowish, gray turf, 10–25 mm. tall (with a pinkish buff to orange buff line at margin of the upper surface of the substratum); on rolled oats the height is 42–45 mm.; on cornmeal, 25–35 mm.; on starch paste, 20–25 mm.; and on grapefruit, 10–19 mm. Dextrose is fermented to some extent but tyrosin is not oxidized. In the maltose-peptone-tyrosin solution an apricot yellow (Ridgway) submerged mycelium is formed.

15. MUCOR GRISEO-CYANUS Hagem, Vid.-Selsk. Skr. M.-N.
Kl. Christiania 1907[7]: 28. *f. 9.* 1908

Forming on bread a dense, mouse gray to light mouse gray (Ridgway) turf, 0.5–1.5 cm. tall; *sporangiophores* 8–18 µ in diameter, tall and short, tall forming the turf, and short remaining only 1–2 mm. in height, *tall sporangiophores* with long (more or less) straight branches, *short sporangiophores* with short (sporangia sometimes appearing almost sessile), usually circinate branches, always with septum immediately above point of insertion of branch; *sporangia* globose, 60–80 μ in diameter (extremes 39–98 μ), encrusted with tiny crystals, at first pale yellowish, becoming deep bluish gray at maturity; *sporangium wall* deliquescent (in sporangia of tall sporangiophores), rupturing (or persistent in sporangia of short sporangiophores), leaving a large or small basal membrane; *columella* globose to oboval, free or slightly adnate, 33–39 × 31–33 μ (extremes 20–58 × 17–47 μ); *spores* uniformly oval, gray in mass, 5–6 × 4–5 μ (a few 8 × 5 μ); *chlamydospores* forming creamy patches (sometimes to the exclusion of sporangiophore production) on surface of substratum, globose, oval to ventricose fusiform, terminal or intercalary, singly or in bead-like chains, 16 μ in diameter or 20 × 10–12 μ; *zygospores* not found (species presumably heterothallic).

This species was collected twice: once, by the writer, on dung (squirrel?), and once on old bones in the Zoological Laboratory of the University of Michigan by Miss C. Reeves. Nos. 12 and 30.

Mucor griseo-cyanus forms a gray turf 15–20 mm. tall on rice and a 10–12 mm. gray turf on grapefruit. It has the ability to ferment dextrose but can not oxidize tyrosin.

16. **Mucor griseo-lilacinus** sp. nov.

Forming on bread a dense, mouse gray (Ridgway) turf becoming in age tinged with drab, 1–1.5 cm. tall; *sporangiophores* 8–20 μ in diameter, at first simple, later with one or two lateral branches which are in turn ramified once to three times (exceptionally eleven times) with branches always terminating in a sporangium, and with a septum above point of insertion of branch; *sporangia* globose or subglobose, 60–80 μ in diameter (extremes 40–100 μ), at first yellowish, becoming dark gray with greenish tinge at maturity; *sporangium wall* deliquescent, leaving a basal membrane; *columella* free or slightly adnate, globose to subglobose, 27–43 μ in diameter (extremes 12–67 μ), tinged lilac gray; *spores* uniform, oval, 4–6 × 3–4 μ (a few large, 8 × 6, 10 × 5 μ), pale gray in mass; *chlamydospores* and *oidia* present in hyphae, chlamydospores globular to barrel-shaped, 10–30 μ in diameter; *hyphae* (especially those near the substratum) with a lilac tinged membrane and often with orange yellow contents; *zygospores* not found (species presumably heterothallic). [PLATE 18, FIGS. 6–10.]

This mucor was obtained from the following sources: stem of decayed grape, decaying pine needle, *Psalliota campestris* (L.) Fr., sheep, rodent, and horse dung. Nos. 1, 3, 11, 15, 16, 20, and 23.

The species is characterized by its uniform, oval spores, its globose to subglobose, slightly adnate, columella and the lilac tint in the columellae and hyphae. This color is sometimes darker (pale purplish) in the hyphae near the substratum.

Mucor griseo-lilacinus forms a drab gray to light drab (Ridgway) turf, 10–20 mm. tall on rice and an 8–19 mm. gray turf on grapefruit. It ferments dextrose but does not oxidize tyrosin. The cultures on rice exhibit a pinkish buff line (Ridgway) around the margins of the upper surface of the medium.

17. MUCOR RAMANNIANUS Moeller, Zeitschr. Forst- u. Jagdw. 35: 330. 1903

Forming on bread a dense purplish vinaceous to livid brown (Ridgway) turf, 1–2 mm. tall; *sporangiophores* 2–6 μ in diameter, simple or with one branch, septate; *sporangia* globose, 20–35 μ in diameter (extremes 40 μ), red; *sporangium wall* deliquescent; *columella* free, globose, 4–10 μ in diameter; *spores* minute, globose, subangular, tinged pink, 2–3 μ in diameter; *zygospores* not found (species presumably heterothallic).

This species was isolated from soil in coniferous woods and from decayed carrot. Nos. 2 and 62. Lendner says, "the coloration of the sporangia is probably due to interstitial substance," but examination of the spores with oil immersion has shown them to be distinctly tinged with pink.

Mucor Ramannianus varies but little. On bread and rice the height is 2 mm., but on grapefruit it does not exceed 0.5 mm. The color on rice is pale to light brownish vinaceous (Ridgway) while on grapefruit it is much brighter, light Corinthian red (Ridgway). This is the only species tested which did not ferment dextrose. Nor does it oxidize tyrosin.

18. MUCOR SPINESCENS Lendner, Bull. Herb. Boissier II. 8: 79. 1908; Les Mucorinées de la Suisse, 89. Berne, 1908

Forming on bread a dense, fuscous (Ridgway) turf, 1–3 mm. tall; *sporangiophores* 8–12 μ in diameter, simple or branched; *sporangia* globose, 74–98 μ in diameter (a few 50 μ), brownish black, not transparent, encrusted with crystals about 2 μ long; *sporangium wall* deliquescent, leaving a large or small basal membrane; *columella* free, oval, pyriform, conical, or elongated, mostly oval apiculate, usually with one to five spines (exceptionally up to twelve) at the apex, although sometimes smooth, 21–43 × 14–25 μ, brown; *spores* globose (a few irregular), 5–8 μ (a few 4 μ) in diameter, dark brown; *zygospores* not found (species presumably heterothallic).

This species was collected twice: from soil in greenhouse, and on decayed Brazil nut. Nos. 44 and 75. It is closely related to *Mucor plumbeus*, but differs in its habit of growth (*M. plumbeus* is 1 cm. tall), smaller sporangia, larger and smooth spores.

Mucor spinescens has never been found to exceed 8 mm. on any medium on which it has been grown and usually it is but from 2–5 mm. tall. On levulose and on dextrin gelatin it forms a dark brownish gray turf 8 mm. tall. On rice the turf is chaetura black (Ridgway) and only 3 mm. tall, while on grapefruit the turf is 4 mm. tall and fuscous (Ridgway). Fermentation of dextrose was obtained and the species is capable of slowly oxidizing tyrosin.

VI. DISCUSSION

1. TESTS FOR ZYGOSPORES

With the single exception of *Mucor proliferus*, zygospores were not found in any cultures of the heterothallic species studied. This is accounted for by the fact that single spore cultures formed the starting point for the study of every number isolated. Consequently it was deemed necessary to test the various collections of the same and of closely related species for zygospore production. In a preliminary set glucose gelatin was used, but in the final experiments Blakeslee's agar, the formula of which has been given, was used. Petri dishes were inoculated with four numbers of mucors and the cultures were examined when growth had resulted in a contact of the hyphae of all the four numbers. With the exception of *Mucor spinescens*, *M. sphaerosporus*, and Nos. 9 and 32 (*M. abundans*), all of the species collected were tested. In all about one hundred fifty different pairs of combinations were used, but the results proved negative in every case.

2. TAXONOMIC CHARACTERS

As has already been stated in the taxonomic division of the work, the author has disregarded some of the usage of past writers in the compilation of his key and specific descriptions. This has been done only after careful consideration and the subsequent belief that, by so doing, matters might be simplified and put on a surer basis than heretofore. Fischer (1892) regarded the grouping of the genus *Mucor* into sections according to branching "nur als eine provisorische Zusammenstellung." Yet Lendner (1908), Hagem (1908), and Jensen (1912) use the same method of separation, and as a result we find that there is considerable confusion and disagreement. To show this more clearly let us consider a few cases. *Mucor strictus* Hagem was placed by its author with the unbranched forms, but Lendner considers that it belongs in the *Cymo-Mucor* group and places it accordingly. *Mucor sphaerosporus* Hagem and *M. griseo-cyanus* Hagem, although classed by Hagem in the *Racemo-Mucor* group, are transferred to the cymose group by Lendner. *Mucor hiemalis* Wehmer, which Hagem calls a *Racemo-Mucor*, is held by Lendner to belong to the unbranched forms. *Mucor silvaticus* Hagem, placed in the *Cymo-Mucor* group by its author, is transferred to the *Racemo-Mucor* group by Lendner. Thus it appears, not only that the terms racemose and cymose, as applied to the branching in this genus, are interpreted by different authors in various ways but also that authors are disagreed as to whether forms are to be considered as simple or branched.

It has been the writer's experience that a mucor which never possesses a branched sporangiophore is a rare occurrence; for a careful search of the culture will usually reveal some branches which are likely to be overlooked, since they are near the substratum. Lendner (1908, p. 55) points out this difficulty. Practically it amounts to the necessity of deciding whether or not branching, if found, is abnormal. The writer believes this to be too difficult, as his work on the group has proved. Thus this means of separation has been avoided in the key and descriptions which this work contains.

Lendner (*l.c.*) describes the *Racemo-Mucor* group as follows: "The filament is early terminated by a sporangium, then branches arise along the principal sporangiophore and never surpass it. This group comprises the species usually little branched." The *Cymo-Mucor* group is defined by him thus: "There is formed below the terminal sporangium a second branch surpassing the first, then on this second there arises a third which surpasses the second. The insertion of the ramifications is usually alternating; as a result there is produced a very characteristic zig-zag appearance." Hagem gives no explanation of his use of these terms, but it appears from his figures and descriptions that in some cases he departs from the usage of past writers. For example, he classifies *Mucor sphaerosporus* and *M. griseo-cyanus* as racemosely branched, although his figures show that Lendner follows past usage in referring them to the cymose group of *Mucor*. Thus we have confusion arising from opposing conceptions of terms. It will be necessary to consider the terms applied to branching.

According to Sachs (1874), De Bary (1887), Schneider (1905), and Strasburger (1912) the two kinds of branching are monopodial and dichotomous; Jost (1907), on the contrary, uses the terms lateral branching and dichotomy. As we are not concerned with the latter we shall consider only the monopodium.

In the monopodium there is present a central axis with a growing point at its apex containing the apical cell. Branching in the monopodium, unlike the process in the dichotomy where a division of the apical cell results in a forking of the main axis, takes place by the development of axillary buds situated near or at some distance from the growing point of the stem. These lateral branches develop by the growth of apical cells. When the lateral branches remain shorter than the persistent main axis a racemose type of branching is evident. When, on the contrary, one or more lateral branches exceed the main axis, sometimes even assuming a central position, a cymose system of branching results. See Sachs (1874, p. 183). This applies in general to the higher plants.

According to Brefeld (1872), the germination of a spore of *Mucor Mucedo*, which may be regarded as typical for the genus, takes place in the following manner: the spore swells and there are produced one or several germ tubes which grow very rapidly and soon begin to branch in all directions, so that an irregularly much-branched thallus is produced. It should be noted that there is no differentiation of the plant body into a specialized apical cell, such as is found in the higher plants. There may be, however, a correlation between the relatively simple plant body and the lack of a fixed branching system.

The vegetative condition may continue for a brief period or indefinitely, depending upon experimental conditions. Under usual laboratory conditions the vegetative period is short (twenty-four to thirty-six hours), and sporangiophores are produced as perpendicular branches arising from the thallus. In some species the growth of the sporangiophore stops with the formation of the apical sporangium; in other species, after the formation of a terminal sporangium, growth starts again, with the production of a lateral branch from some part of the sporangiophore, and continues until a sporangium is formed at the tip of this branch. On one hypha or branch the same process may be again repeated. (De Bary, 1887, p. 46.)

This account of the development of the sporangiophore apparently does not harmonize with De Bary's (1887) statement that "both growth and branching follow the laws which prevail generally in the vegetable kingdom." For it may be said that a comparison of the development of branching systems in the higher plants with those in the genus *Mucor* shows little similarity between them. Although, perhaps, the stems and inflorescences of the higher plants may be analogous to the sporangiophores and sporangia of *Mucor*, it can scarcely be maintained that there exists a homology between them. It appears then advisable not to apply the terms used to describe the branching of the higher plants to the sporangiophores of *Mucor*. Even if the writer's views on this matter can not be accepted, the impracticability of using the terms is sufficient reason for discarding them.

The characters which experience has proven reliable for specific determination are as follows: turf, columella, spores, sporangium, sporangium wall, and chlamydospores. These are given in the relative order of their importance. The height, color, and nature of the turf must be considered. Inasmuch as the term turf includes only the aerial part of the plant, the height of the turf is the length of the sporangiophores, and is expressed either in millimeters or in centimeters. Contrary to current opinion, there is rather a wide range of color in the genus *Mucor*, varying from palest gray (almost white), through yellow and red to dark gray, brown, or black. Ridgway (1912) has been used as a color standard throughout the work. The nature of the turf is either loose, in which case it usually collapses with age, or compact, when it remains erect even on the drying out of the culture.

The relation of the sporangium wall to the columella, as well as the shape and size of the latter, is important. The word "free" has been used to designate the condition in which the sporangium wall is separate from the columella and is attached to the sporangiophore at the base of the columella; whereas the term "adnate" has been used in cases where the sporangium wall is adherent to the columella at its broadened base. (*Cf.* "nicht aufsitzend" or "libre" and "aufsitzend" or "susjacente.") In some species, especially those having globose or oval columellae, the shape is constant; in others a wide variation in shape and size of columellae is found. When the latter is true, the small columellae are mostly uniformly globose or oval; the large columellae, on the contrary, exhibit a strong tendency to a different shape. Thus in the descriptions when the shape of the columella is given as "oval to pyriform" it is to be understood that the larger columellae are mostly pyriform. In a few species, for example *Mucor varians*, the columellae are extremely variable and run the gamut of all the shapes.

In a consideration of the spores the shape and size must be noticed, and we find the spores either uniform or variable. If uniform, the shape may be globose, oval, elliptical, etc.; if variable, some combination of the above-mentioned shapes together with irregular spores, subreniform, subfusiform, etc.

Within certain limits the size of the sporangium is dependable, i. e., the sporangia may be large (200–500 µ in diameter) or small (not exceeding 100 µ in diameter and usually 60–80 µ). The wall of the sporangium is also important, being either deliquescent, rupturing, or persistent.

A certain group of species of *Mucor* can be separated from the rest by the fact that chlamydospores are present in the sporangiophores. *Mucor racemosus* and *M. sphaerosporus* would be included in such a separation of species.

As has already been stated, sixty-six collections of the genus *Mucor* were made. These were studied carefully from uniform bread cultures made in the previously described manner, and from the data obtained they were tabulated according to their specific individuality. In this preliminary arrangement twenty-six different groups were obtained, which, by careful comparison, were reduced to twenty-four groups. Nine of these aggregates were, after a careful study, referred to four species, three of which were undescribed. Thus the sixty-six collections of *Mucor* were distributed through eighteen species.

In TABLE I two species, *Glomerula repens* and *Zygorhynchus Vuillemini*, have been excluded from *Mucor*, although Lendner includes both *Zygorhynchus* and *Glomerula* in that genus. He examined specimens of the former only. A study of *Glomerula repens*, from two separate collections, has convinced the writer that this species can not be placed under the genus *Mucor* because the hyphae may serve as stolons. For example, if the tip of a hypha touches the wall of the culture container, a cluster of rhizoid-like hyphae is formed, and often from this cluster sporangiophores are developed. Moreover, the general habit of growth is unlike that of the species of *Mucor*. An increase in lack of sporangia production often results in a cottony, dense, sterile mass of buff mycelium. *Zygorhynchus*, on account of its unequal suspensors, not to mention its very slight production of sporangia and abundant zygospore formation, should, in the writer's opinion, be kept as a separate genus.

3. EXPERIMENTAL

The experiments, in so far as their original purpose is concerned proved almost entirely negative. It was thought that striking cultural results might be obtained from the experiments which might form the basis for a physiological separation of species. Little of this kind was observed. On the contrary, the experiments showed that the genus *Mucor* is composed of a physiologically close group of species, exhibiting only minute cultural variations. Sometimes these differences were correlated with species, but sometimes they occurred sporadically. A concrete example of this latter phenomenon was the production of a yellow color in or on the substratum. This was obtained on bread, on rice, and in maltose-peptone-tyrosin solution. It probably represents the storing up of excess food material, as a microscopic examination showed the color to be due to yellow globules in the hyphae; moreover, this color production occurred only in cultures with abundant food supply.

The results of the experiments with carbohydrates plus asparagin, on the one hand, and mineral salts (including ammonium nitrate), on the other, which show that the mucors grow much better in the first case than in the second, may, it is believed, offer some indication as to the reason why complex media (rolled oats, bread, rice, cornmeal, etc.) are better than simpler media.

Fermentation is, apparently, a more widespread process in this genus than has hitherto been supposed, knowledge of the forms which can produce this phenomenon being limited to some twenty species. Wehmer (1907) has given a clear and concise summary of the work published on the subject. The writer's results, positive except in one case, have added twelve species to the list.

Hagem (1910) found that tyrosin was oxidized by several species of *Mucor* and *Rhizopus*, with the production of a red or reddish brown solution. He thinks that this change is brought about by the enzyme tyrosinase. In the cases of *Mucor strictus*, *M. silvaticus*, *M. plumbeus* the color was pale red, in *M. racemosus* and *M. christianiensis*, dingy brownish red, but in *Rhizopus nigricans* and *R. nodosus* the solution was dark red. The writer's experiments showed that the solution was colored dark reddish brown, with the formation of a dark brown precipitate, by *Mucor griseosporus* and *M. coprophilus*. In the case of *Mucor proliferus*, *M. spinescens*, and *M. plumbeus* the solution was pale brown and a brownish black precipitate was observed. With *Glomerula repens* a brownish tinge to the solution was obtained, while the aerial growth was distinctive in that it was pinkish buff (Ridgway).

The objection might be raised that bread is a variable substance and therefore is unsuitable for a standard culture medium. A comparison of cultural results obtained, during the past three years, with bread obtained from different sources has proven this objection negligible. The bread used is the ordinary baker's white bread, such as is readily obtainable at any grocery store. It is thought that the use of bread is simpler than employing such complex media as Lendner's "mout gelatinisé."

VII. SUMMARY

1. From over one hundred collections, thirty-seven species representing fourteen genera of the Mucorales have been obtained.

2. After having tried various substances, bread was adopted as a standard culture medium for taxonomic purposes.

3. The carbohydrates with regard to their availability as a source of food supply for the mucors, as exhibited by their growth, may be arranged as follows, the best being given first: levulose, dextrin, glucose, lactose, maltose, inulin, and saccharose.

4. Organic nitrogen compounds are better than ammonium nitrate.

5. Seventeen species of *Mucor* were found capable of fermenting dextrose-peptone solution.

6. *Mucor griseosporus* and *Mucor coprophilus* can oxidize tyrosin in a maltose-tyrosin-peptone solution, with the production of a red coloration of the solution and the formation of a dark brownish black precipitate.

7. The terms racemose and cymose should not be employed to describe branching in this group, because of the confusion which has arisen through their use, not to mention the lack of homology between a sporangiophore and a branch of one of the higher plants.

8. Sixty-six collections of the genus *Mucor* have been studied in great detail under uniform conditions in standard bread cultures, and they have been referred to nineteen species, six of which are new: *Mucor griseo-lilacinus*, *M. varians*, *M. coprophilus*, *M. aromaticus*, *M. griseosporus*, and *M. abundans*.

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Explanation of plates 17-20

PLATE 17

Mucor abundans Povah. 1. Sporangiophores showing various kinds of branching, about natural size. 2. Upper portion of sporangiophore showing branch detail, ×350. 3. Lower portion of sporangiophore, ×170. 4. Columellae, ×350. 5. Spores. ×350. 6. Chlamydospores from within substratum, ×75.

Mucor aromaticus Povah. 7. Columellae, ×170. 8. Swollen branched apex of sporangiophore. ×75. 9. Almost mature sporangium, ×170. 10. Spores, ×170. 11. Sporangiophores about three fourths natural size.

PLATE 18

Mucor griseosporus Povah. 1. Sporangiophores about one half natural size. 2. Portion of sporangiophore showing detail of branching, ×170. 3. Lateral sporangium, ×75. 4. Columellae, ×170. 5. Spores, ×350.

Mucor griseo-lilacinus Povah. 6. Sporangiophores, × 3. 7. Portion of sporangiophore showing insertion of branch, ×170. 8. Apex of sporangiophore, ×170. 9. Columellae, ×170. 10. Spores, ×350.

PLATE 19

Mucor coprophilus Povah. 1. Sporangiophore, about one half natural size. 2. Columellae, ×170. 3. Lateral deciduous sporangium, ×350. 4. Spores from small lateral sporangia, ×350. 5. Spores from large terminal sporangia, ×350.

Mucor proliferus Schostak. 6, 7. Formation of gametes, ×75. 8. Union of gametes, ×75. 9. Immature zygospore, ×75. 10. Mature zygospore, ×170.

PLATE 20

Mucor varians Povah. 1. Sporangiophores, ×2. 2. Columellae, ×350. 3. Spores. ×350. 4. Apex of sporangiophore. ×75. 5. Proliferation of sporangiophore. ×75. 6. Proliferation of columella. ×75.

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INDEX TO AMERICAN BOTANICAL LITERATURE

1916-1917

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the word America being used in the broadest sense.

Reviews, and papers that relate exclusively to forestry, agriculture, horticulture, manufactured products of vegetable origin, or laboratory methods are not included, and no attempt is made to index the literature of bacteriology. An occasional exception is made in favor of some paper appearing in an American periodical which is devoted wholly to botany. Reprints are not mentioned unless they differ from the original in some important particular. If users of the Index will call the attention of the editor to errors or omissions, their kindness will be appreciated.

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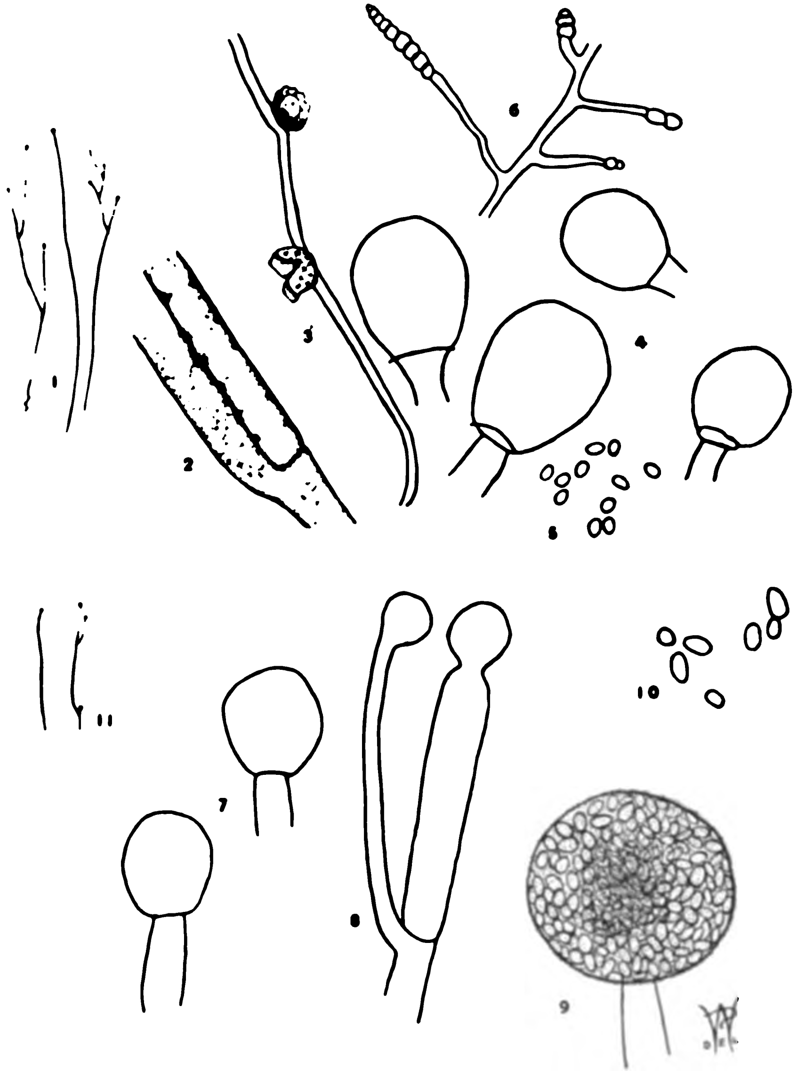
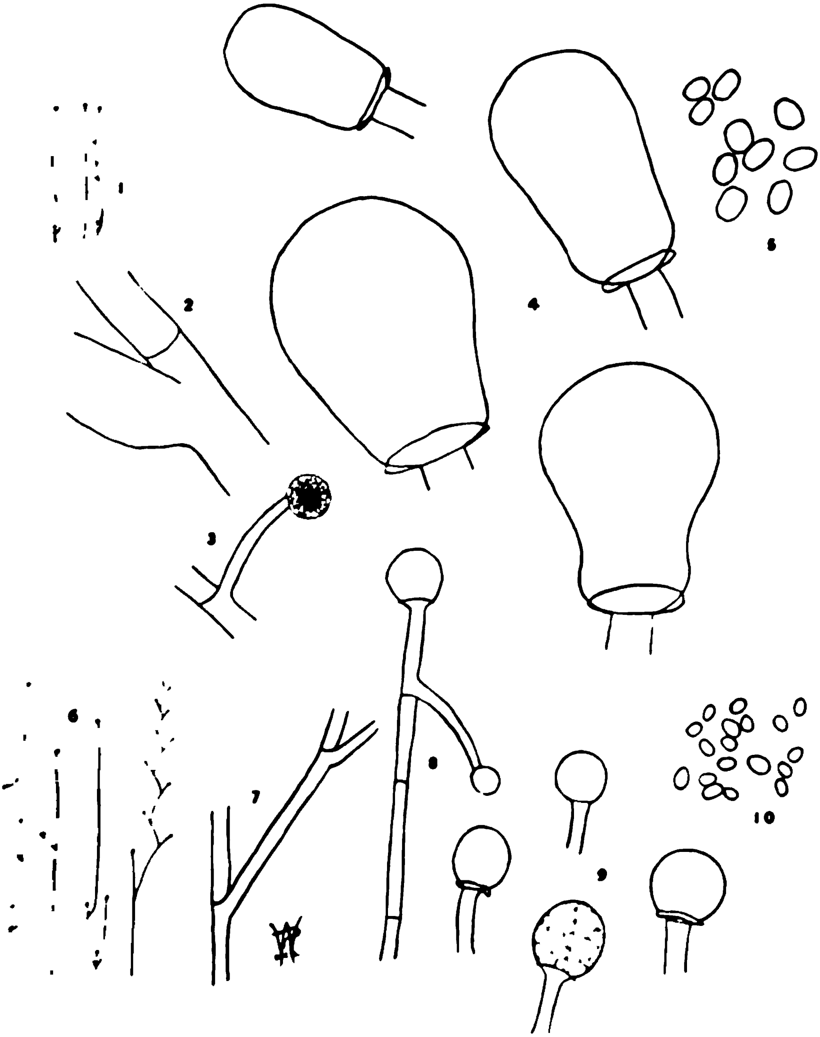
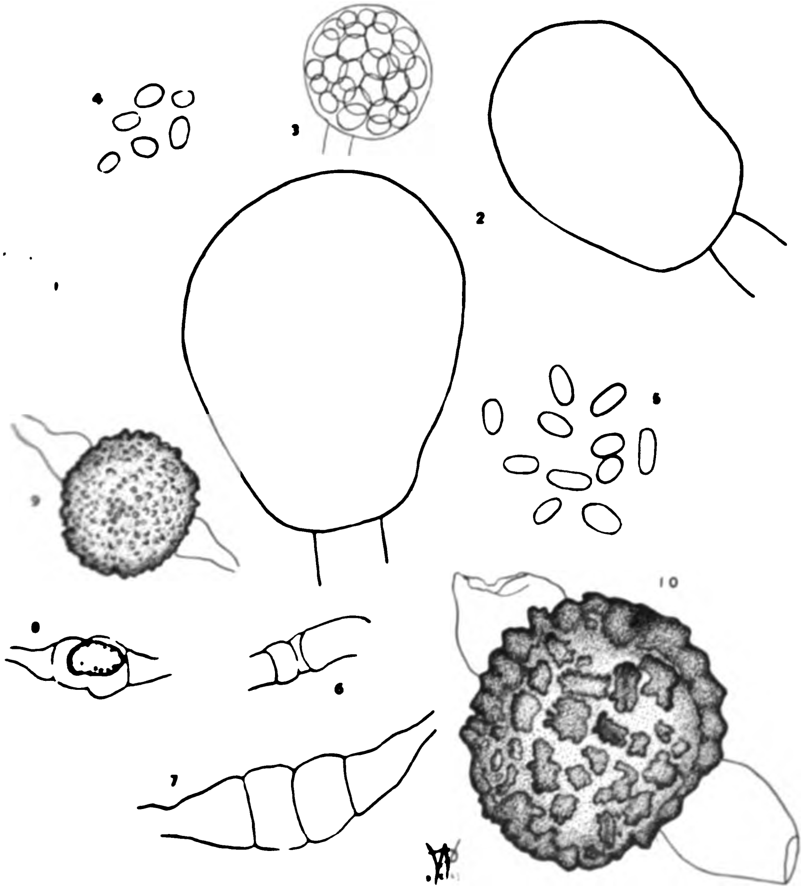


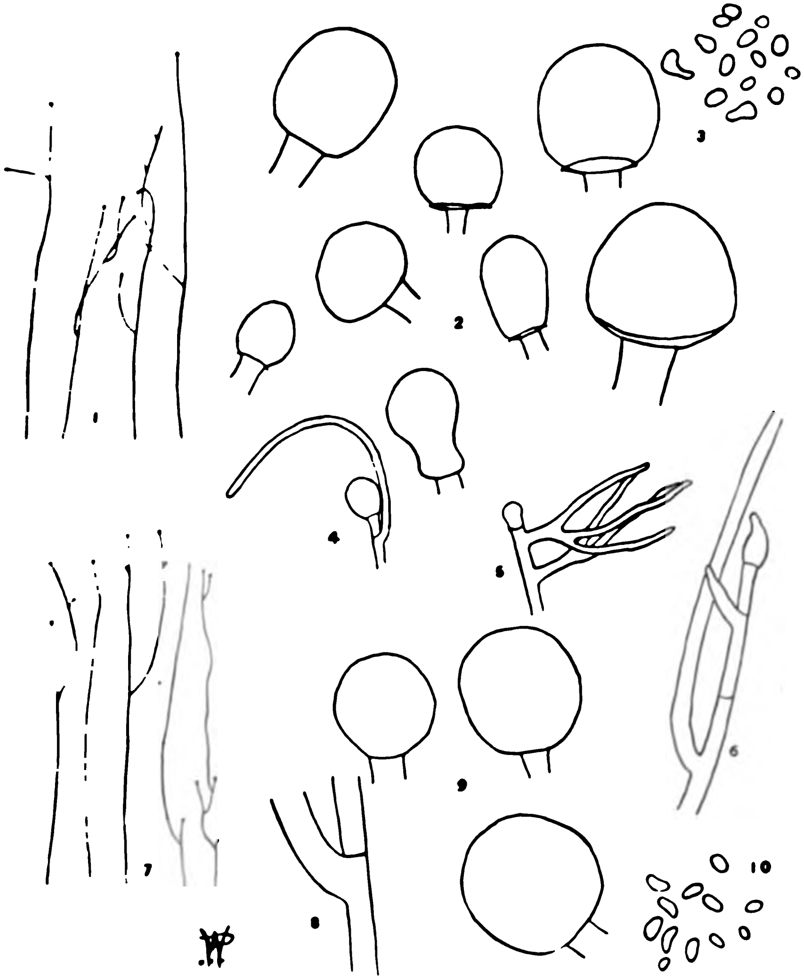
1-6. MUCOR ABUNDANS Povah
7-11. MUCOR AROMATICUS Povah



1-5. MUCOR GRISEOSPORUS Povah
6-10. MUCOR GRISEO-LILACINUS Povah



1–5. MUCOR COPROPHILUS Povah
6–10. MUCOR PROLIFERUS Schostak



1–6. MUCOR VARIANS Povah
7–10. MUCOR HIEMALIS Wehmer

Vol. 44 No. 7

BULLETIN

OF THE

TORREY BOTANICAL CLUB

JULY, 1917

Some noteworthy lichens from Jamaica

Lincoln W. Riddle

(WITH PLATE 21)

In the spring of 1912, Dr. Joseph A. Cushman, Assistant Curator of the Boston Society of Natural History, collected in the Island of Jamaica, in the West Indies, a set of lichens representing 109 species and varieties. A study of these has resulted in the discovery of two new species and of a number of other species of sufficient interest to be worthy of record. To the discussion of these species has been added a revision of the American species of *Megalospora*, four of which occur in Jamaica. A complete set of the lichens collected by Dr. Cushman has been deposited in the herbarium of the Boston Society of Natural History.

NEW SPECIES

1 **Buellia rinodinospora** Riddle, sp. nov.

Thallus epiphloeodes crustaceus uniformis effusus haud limitatus, albidus vel cinerascenti-albidus subnitidus, crassitudine mediocris, inaequalis partim rimulosus partim rimoso-areolatus et demum diffractus; KOH flavescens; hypothallo nullo. Apothecia mediocria, 0.5–1.0 mm. lata, subelevata, nitida, primum concava demum plana vel satis convexa, rotunda regularia; disco scabro, nudo, castaneo vel fusco-nigricante nunquam atro; margine proprio nigro, persistente, primum crasso integro demum tenue crenulato; epithecio fulvo; hymenio decolore, circ. 180 μ altit.; excipulo et hypothecio fusco-nigricante. Asci 8-spori. Sporae fuscae oblongae sat curvatae, biloculares placodiomorphae,

[The Bulletin for June (44: 267–320. *pl. 17–20*) was issued June 13, 1917.]

loculis poro confluentibus, 36–50 × 15–20 μ. [PLATE 21, FIGS. 1, 4.]

On bark, Newcastle, Jamaica, March 1912, *J. A. Cushman 155*.

This species is distinct from all other *Buellias* in the large size and polar-bilocular character of the spores. Wainio (Act. Soc. Sci. Fenn. 7: 172. 1890) describes a *Buellia placodiomorpha* with a similar type of spore but with four cells and reaching a size of only 19 × 10 μ. From species of *Rinodina*, this new species can be distinguished by the apothecia being of the lecideine type rather than the lecanorine.

2. **Chiodecton** (Sect. ENTEROGRAPHA) **leiostictum** Riddle, sp. nov.

Thallus crustaceus crebre contextus uniformis effusus, linea nigra limitatus, albidus vel demum sat sordide ochroleucus opacus, crassus (0.15–0.2 mm. crassit.) rimuloso-areolatus; KOH intense flavescens dein rubescens; hypothallo nullo. Apothecia numerosissima, thallo immersa, punctiformes rotundata vel subdifformia haud elongata, minuta, 0.12–0.16 mm. lata, seriata uniserialia vel interdum serie ramosa disposita serialibus rectis vel flexuosis, aut rarius partim irregulariter aggregata; disco atro parum pruinoso dein nudo, plano, superficiem thallo aequante; margine distincto nullo; epithecio fuligineo-nigro; amphithecio supra fuligineo-nigro infra decolore; hypothecio decolore; hymenio decolore, 100–120 μ altit. Asci 8-spori. Sporae decolores anguste oblongae, 5–8 loculares loculis cylindricis vel satis rotundatis, 20–30 × 4–6 μ, halonae 4–5 μ crasso indutae. [PLATE 21, FIGS, 3, 5.]

On old decorticated wood, Montego Bay, Jamaica, March 1912, *J. A. Cushman 15*.

In 1886 (Flora 69: 104), Nylander published a list of the Graphidaceae collected by Charles Wright in Cuba. The list included many new species which were given merely as *nomina nuda*. For most of these no descriptions were ever published. The species just described was named by Nylander (*l.c.*) *Stigmatidium leiostictum*. Through the courtesy of Professor Farlow, I have been able to make a microscopic examination of original material of Wright's Graphideae Cubanae No. 157, cited by Nylander, and it has proved to be identical with the specimens collected by Dr. Cushman in Jamaica. Species of *Chiodecton* Sect. *Enterographa* with spores more than four-celled are comparatively few in number, and among these *Ch. leiostictum* is distinct in the serial arrangement of the punctiform apothecia.

NOTEWORTHY SPECIES NOT PREVIOULSY RECORDED FROM JAMAICA

1. ANTHRACOTHECIUM OCHRACEO-FLAVUM (Nyl.) Muell. Arg. Linnaea **43**: 44. 1880.

Verrucaria ochraceo-flava Nyl. Expos. Pyren. 50. 1858.

On bark, Montego Bay, *J. A. Cushman 122.* Known elsewhere from Cuba, Mexico, Colombia, and the East Indies.

2. HEUFLERIA SEPULTA (Mont.) Trevis. Flora **44**: 23. 1861.

Astrothelium sepultum Mont. Ann. Sci. Nat. Bot. II. **19**: 74. 1843.

On bark, Mandeville, *J. A. Cushman 152.* Known elsewhere from Cuba, Guiana, Brazil, and Peru.

3. LAURERA GIGANTOSPORA (Muell. Arg.) Zahlbr.; Engler & Prantl, Nat. Pflanzenfam. I^{1*}: 71. 1903.

Bathelium gigantosporum Muell. Arg. Bot. Jahrb. **6**: 394. 1885.

On bark, Mandeville, *J. A. Cushman 44.* Known previously from the original collection only, made by Charles Wright in Cuba; but closely related and perhaps not specifically distinct from **Laurera megaspermum** (Mont.) Riddle, comb. nov. (*Trypethelium megaspermum* Mont. Ann. Sci. Nat. Bot. II. **19**: 68. 1843), which is known from Cuba, Guiana, and Brazil.

4. GRAPHINA CHRYSOCARPA (Raddi) Muell. Arg. Flora **63**: 41. 1880.

Opegrapha chrysocarpa Raddi, Atti Soc. Ital. Sci. **38**: 34. 1820.

On bark, Mandeville, *J. A. Cushman 49.* A striking species known elsewhere from Porto Rico, Costa Rica, Colombia, and Brazil.

5. GRAPHINA PLATYGRAPTA Muell. Arg. Flora **71**: 495. 1888.

On bark, Mandeville, *J. A. Cushman 54.* This species was based on material collected by Sintenis in Porto Rico, and hitherto has been known from the original collection only. Owing to the war, I have been unable to see the type, but the species has such distinctive characters, and Mueller-Argau's description applies so well to Dr. Cushman's specimens, that there can be no doubt as to the identity of the two. *G. platygrapta* belongs to the section *Platygraphopsis* (see PLATE 21, FIGS. 2, 6). The original description gave the spore-measurements as 150 × 30 μ. I find that they vary from 150–180 × 30–50 μ. An examination of Wright's Graphideae Cubanae No. 4, labelled with a manuscript name of Nylander's in the Tuckerman Herbarium, proves that it is the same as Dr. Cushman's Jamaica specimens. This species is, therefore, now known from Cuba, Jamaica, and Porto Rico.

6. PHAEOGRAPHINA QUASSIAECOLA (Fée) Muell. Arg. Mem. Soc. Phys. Hist. Nat. Genève **29**^{8}: 47. 1887.

Thecaria quassiaecola Fée, Essai Crypt. 97, *pl. 1, f. 16.* 1824.

This is a striking and peculiar species in which the prominent apothecia vary from elongated-lirelliform to oblong and even entirely circular. Occasional specimens occur with all the apothecia circular, and such specimens would easily be mistaken for a *Gyrostomum*. Mueller-Argau says (*op. cit.* 48) that Fée's citation of the type-locality as "America" must have been a mistake as the original specimen in Fée's herbarium came from Madagascar. And hitherto the species has been recorded from the Old World only: from tropical Africa, Ceylon, New Caledonia, and Australia. But it appears to be sufficiently common in Jamaica, as I have in my herbarium the following specimens from that island:—Mandeville, March, 1912, *J. A. Cushman 52;* also January, 1909, *A. E. Wight 66;* near Troy, September, 1906, *Elizabeth G. Britton & Delia W. Marble 265;* also June, 1909, *A. E. Wight 140a, 202, 208.* Furthermore, the specimen of Wright's Graphideae Cubanae No. 7, in the Tuckerman Herbarium, proves to be this species, having been incorrectly determined as "*Graphis scalpturata* var. *plurifera* Nyl." which is a synonym of *Phaeographina caesiopruinosa* (Fée) Muell. Arg. Both *Ph. scalpturata* and *Ph. caesiopruinosa* belong to the Section *Eleutheroloma*, in which the amphithecium is black at the sides only and colorless beneath; while *P. quassiaecola* belongs to the Section *Pachyloma*, in which the amphithecium is completely black and very thick at the base. With the correct identification of this Cuban specimen, we have three stations for the species in the West Indies.

7. LECANACTIS PREMNEA var. **pluriloculаris** (Nyl.) Riddle, comb. nov.

Lecidea pluriloculаris Nyl. Ann. Sci. Nat. Bot. IV. **15**: 49. 1861.

On bark, Montego Bay, *J. A. Cushman 67.* Known elsewhere from Cuba, Colombia, Peru, New Caledonia, the East Indies, and India.

8. **Ocellularia chionostoma** (Nyl.) Riddle, comb. nov.

Thelotrema chionostoma Nyl. Ann. Sci. Nat. IV. **19**: 329. 1863.

On bark, Montego Bay, *J. A. Cushman 106.* Known previously from the original collection only, made by Charles Wright in Cuba.

9. PHAEOTREMA PLATYCARPOIDES (Tuck.) Muell. Arg. Flora **69**: 311. 1886.

Thelotrema platycarpoides Tuck. Proc. Am. Acad. Arts Sci. **6**: 270. 1864.

On bark, Montego Bay, *J. A. Cushman 80.* Known previously from the original collection only, made by Charles Wright in Cuba.

10. **Lopadium castaneum** (Mey. & Flot.) Riddle, comb. nov.

Lecanora subfusca var. *castanea* Mey. & Flot. Nova Acta Acad. Caes. Leop. Carol. **19** (suppl. 1): 224. 1843.

On bark, Newcastle, *J. A. Cushman 29.* Known elsewhere only from Brazil.

11. PERTUSARIA VERRUCOSA (Fée) Mont. Ann. Sci. Nat. II. **19**: 78. 1843.

Trypethelium verrucosum Fée, Essai Crypt. 66. *pl. 18, f. 3.* 1824.

On bark, Newcastle, *J. A. Cushman 26*, and Mandeville, *J. A. Cushman 50.* Known elsewhere from Guadeloupe and Guiana.

12. RAMALINA PERUVIANA Ach. Lich. Univ. 599. 1810.

This species seems to be common in Jamaica. I have the following specimens in my herbarium: Mandeville, *A. E. Wight 95. 96; Elizabeth G. Britton 437; J. A. Cushman 47;* Catadupa, *J. A. Cushman 14.* I have compared one of the specimens collected by Wight with the type-specimens of Acharius in the Botanical Museum at Helsingfors, Finland, and the determination is certain. Known elsewhere from Porto Rico and Peru.

MEGALOSPORA

In an enumeration of Jamaica lichens in May, 1912, I described in Mycologia (4: 129) two new species of *Megalospora: M. Cummingsiae* and *M. jamaicensis*. The following autumn, I had an opportunity to study all of the material of this genus, including a number of authentic specimens in the collection of Mueller-Argau, at the Boissier Herbarium, Chambèsy, Switzerland. This led me to a detailed study of the principal species and as four of these occur in Jamaica it will not be out of place to present, herewith, the results of this study. Two of the species are variable but with well-marked varieties, which have been recognized by various authors and are certainly worthy of varietal names.

The genus *Megalospora* was established by Meyen and Flotow in 1843 (Nov. Act. Acad. Caes. Leop. Carol. 19 [suppl. 1]: 228), with *M. sulphurata* as the type-species. The species were included under *Lecidea* by Nylander; under *Patellaria* by Mueller-Argau; and under *Heterothecium* Sect. *Psorothecium* by Tuckerman. But in accordance with current ideas of the value of spore-characters in the classification of crustose lichens, Zahlbruckner (in Engler-Prantl, Nat. Pflanzenfam. I^{1*}: 134. 1905) has revived *Megalospora* as a distinct genus, distinguished from the other Lecideaceae by the thick-walled, two-celled spores of large size. The commonest species is the variable *M. versicolor* (Fée) Zahlbr., of which many of the other proposed "species" are synonyms or varieties.

The following key and citations of species and synonymy will serve to summarize the results of my study of the American species and varieties of *Megalospora*.

A. Growing on evergreen leaves .... 5. *M. premneella*
AA. Growing on the bark of trees.
B. Spores straight (PLATE 21, FIGS. 9, 10).
C. Thallus more or less straw-colored, apothecia with fulvous disk and straw-colored margin .... 1. *M. sulphureorufa*
CC. Thallus ashy or whitish, apothecia variously colored, but the margin never straw-colored .... (2. *M. versicolor*).
D. Margin white or pallid, contrasting with the fulvous, aeruginous, or black disk .... 2b. *M. versicolor* var. *livido-cincta*
DD. Margin concolorous with the disk or nearly so, at least not pallid.
E. Apothecia variously colored: carneous, fulvous, aeruginous, or black, regular in form, and rarely over 1.5 mm. diam.
2a. *M. versicolor* var. *dichroma*

EE. Apothecia black and difform, reaching 3 mm. diam.
2c. *M. versicolor* var. *major*
BB. Spores curved.
C. Thallus smooth or granular, but not sorediate; spores 50–65 × 28–35μ, reniform, the individual cells little longer than wide (PLATE 21, FIG. 7.)
(3. *M. sulphurata*)
D. Thallus smooth or nearly so, apothecia 1.5–3 mm. diam.
E. Apothecia bay-brown to dark chestnut-brown, blackening only when old............3a. *M. sulphurata* var. *genuina*
EE. Apothecia always black....3b. *M. sulphurata* var. *nigricans*
DD. Thallus granular-uneven, apothecia 3–6 mm. diam., blackening.
3c. *M. sulphurata* var. *megacarpa*
CC. Thallus verrucose, granulate, and powdery-sorediate; spores 70–125 × 20–30μ, the individual cells about twice as long as wide (PLATE 21, FIG. 8)................................4. *M. Cummingsiae*

1. **Megalospora sulphureorufa** (Nyl.) Riddle, comb. nov.

Lecanora sulphureorufa (Nyl. Bull. Soc. Linn. Norm. II. **2**: 69. 1868.

Megalospora jamaicensis Riddle, Mycologia **4**: 129. 1912.

JAMAICA: Newcastle, *J. A. Cushman 24;* without definite locality, *Clara E. Cummings 138, 142.*

At the time that *M. jamaicensis* was published, I was sure that there was no American species to which the specimens so named could be assigned. But while working at the Boissier Herbarium, I found an authentic specimen of the plant called *Lecanora sulphureorufa* Nyl., based on three collections from two islands, New Caledonia and Lifu, situated between the Fiji Islands and Australia. This proved to be identical with my material from Jamaica. This is a remarkable distribution, and as the species is a conspicuous one, it seems extraordinary that it should never have been collected in South America, if it occurs there.

2. MEGALOSPORA VERSICOLOR (Fée) Zahlbr.; Engler & Prantl, Nat. Pflanzenfam. I¹*: 134. 1905.

Lecanora versicolor Fée, Essai Cryptog. 115. *pl. 28, f. 4.* 1824.

This species occurs in three varieties worthy of receiving names, as follows:—

2a. MEGALOSPORA VERSICOLOR var. **dichroma** (Fée) Riddle, comb. nov.

Lecidea dichroma Fée, Bull. Soc. Bot. Fr. **20**: 319. 1873. According to an authentic specimen in the Boissier Herbarium!

Lecidea incondita Krempelh. Flora **59**: 316. 1876. This was based on the same collection from Brazil (*Glaziou 5520*) as Fée's species.

Lecidea versicolor var. *vigilans* Nyl. Act. Soc. Sci. Fenn. **7**: 461. 1863 (in greater part). Not *Lecanora vigilans* Taylor, London Jour. Bot. **6**: 159. 1847! The type of Taylor's species is in the herbarium of the Boston Society of Natural History. There are two specimens, one from Mauritius and the other from Peru. But they represent two different species, and as the Mauritius specimen, which is cited first in Taylor's original description and should, therefore, be considered the actual type, is a species of *Bombyliospora*, the name *vigilans* Taylor can not be used in connection with *Megalospora versicolor*, even though the specimen from Peru belongs to that species. As the name *vigilans* has been used as a varietal name for both *Megalospora versicolor* and *M. sulphurata*, and is actually a *Bombyliospora*, it will make for clearness to drop it altogether.

According to Fée's original description of *Lecanora versicolor*, the var. *dichroma* corresponds to the typical form of the species, with the apothecia characteristically variable in color; but there is a tendency toward darkening, and the specimens having all the apothecia entirely black, but still small and regular, as is frequently the case, are to be considered merely as mature plants of this variety.

JAMAICA: without definite locality, *Clara E. Cummings 151, 153;* also in Merrill's Lich. Exsic. No. 230.

Specimens examined from Cuba, Porto Rico, Mexico, Costa Rica, Colombia, Venezuela, and Brazil (spec. authent.!); recorded also from Australasia and from Africa.

2*b*. MEGALOSPORA VERSICOLOR var. **livido-cincta** (Muell. Arg.) Riddle, comb. nov.

Patellaria livido-cincta Muell. Arg. Flora **64**: 227. 1881.

Patellaria versicolor var. *livido-cincta* Muell. Arg. Bull. Soc. Roy. Bot. Belgique **32**: 141. 1894.

Specimens examined from Mexico, Costa Rica, and Brazil (type!).

2c. MEGALOSPORA VERSICOLOR var. **major** (Wainio) Riddle, comb. nov.

Lecidea versicolor var. *major* Wainio, Act. Soc. Sci. Fenn. 7^2: 36. 1890. Authentic specimen examined from Brazil!

3. MEGALOSPORA SULPHURATA Mey. & Flot. Nov. Act. Acad. Caes. Leop. Carol. 19 (suppl. 1): 228. 1843.

The species is represented in America by three varieties, as follows:—

3a. MEGALOSPORA SULPHURATA var. **genuina** Riddle, nom. nov.

Patellaria sulphurata var. *vigilans* Muell. Arg. Flora 69: 288. 1886. Not *Lecanora vigilans* Taylor (compare discussion given above under *M. versicolor* var. *dichroma*).

Apothecia primum pallida vel rufescentia vel tandem subnigrescentia.

According to an authentic specimen in the Boissier Herbarium, these are the characters of the original type-form of Meyen and Flotow.

JAMAICA: Gordon Town, 1884, *J. Hart*.

Specimens examined from Mexico, Colombia, Brazil, and the Philippines (spec. orig.!).

3b. MEGALOSPORA SULPHURATA var. **nigricans** (Muell. Arg.) Riddle, comb. nov.

Patellaria vigilans var. *nigricans* Muell. Arg. Flora 64: 227. 1881.

Specimens examined from Mexico, Venezuela, Brazil (type!), and Australia.

3c. MEGALOSPORA SULPHURATA var. **megacarpa** (Nyl.) Riddle, comb. nov.

Lecidea megacarpa Nyl. Ann. Sci. Nat. IV. 11: 260. 1859.

Specimens examined from Costa Rica, Brazil, Ceylon, and Mauritius (spec. authent.!).

4. MEGALOSPORA CUMMINGSIAE Riddle, Mycologia 4: 129. 1912.

JAMAICA: without definite locality, *Clara E. Cummings 129* (type!). Endemic.

5. MEGALOSPORA PREMNEELLA (Muell. Arg.) Zahlbr.; Engler & Prantl, Nat. Pflanzenfam. I^1*: 134. 1905.

Patellaria premneella Muell. Arg. Lich. Epiphyll. 5. 1890.

Specimen examined from Brazil (type!). Endemic.

Explanation of plate 21

All figures were drawn with a camera-lucida: FIGS. 1, 2, and 3, at a uniform magnification of 41 diameters; FIGS. 4–10, at a uniform magnification of 385 diameters The plate has been reduced approximately one half in reproduction. Brown or black coloration is indicated by stippling.

FIG. 1. Vertical section of apothecium of *Buellia rinodinospora* Riddle.
FIG. 2. Vertical section of apothecium of *Graphina platygrapta* Muell. Arg.
FIG. 3. Vertical section of apothecium of *Chiodecton leiostictum* Riddle.
FIG. 4. Spores of *Buellia rinodinospora* Riddle.
FIG. 5. Spore of *Chiodecton leiostictum* Riddle, with mucous envelope.
Fig. 6. Spore of *Graphina platygrapta* Muell. Arg. (the cells semi-diagrammatic).
FIG. 7. Spores of *Megalospora sulphurata* Mey. & Flot.
FIG. 8. Spores of *Megalospora Cummingsiae* Riddle.
FIG. 9. Spores of *Megalospora versicolor* (Fée) Zahlbr.
FIG. 10. Spores of *Megalospora sulphureorufa* (Nyl.) Riddle.

A middle Eocene Goniopteris

EDWARD W. BERRY

(WITH PLATE 22)

The following new species, based upon rather extensive and well preserved material from the middle Eocene of our southern states, seems worthy of special notice. It is referred to the polypodiaceous genus *Goniopteris* Presl, as amended, and it is hoped that the present note will have some influence with students of living ferns in hastening the much to be desired segregation of the unwieldy and more or less unnatural genus *Dryopteris*, in which *Goniopteris* is often included.

Goniopteris claiborniana sp. nov.

Fronds of large size, probably bipinnate, with a stout prominently winged rachis. Pinnae alternate to subopposite, often prevailingly subopposite. Pinnae shortly stipitate, of large size, linear-lanceolate in outline, averaging between 10 cm. and 15 cm. in length by 1.5–3.5 cm. in maximum width, tapering to an extended, attenuated, acuminate tip. Pinnae variable, normally not entirely segregated into individual pinnules but pinnatifid, the margins being separated into dentate, inequilateral segments with upwardly directed points and narrow, inequilateral sinuses extending one fourth to one third of the distance to the stipe. Pinnae sometimes but slightly pinnatifid with short, conical segments, the sinuses extending only one seventh of the distance to the stipe; sometimes deeply pinnatifid, the sinuses extending about half way to the stipe. Basal proximal pinnule often free and entire.

The three types of marginal lobulation are correlated with three types of venation, although naturally the three are connected by every intermediate gradation. These types will be described after describing what I have called the normal type. This is the type that agrees in its more important particulars with that type familiar in Tertiary ferns and referred by paleobotanists to the more or less interrelated and synonymous genera *Lastrea*, *Phegopteris* and *Goniopteris*. It is a type met with in modern, mostly tropical, ferns, variously segregated or aggregated by students of existing ferns in the genera *Lastrea*, *Nephrodium*, *Phegopteris*, *Polybotrya* and *Dryopteris*.

Christensen, perhaps the foremost living fern student, enumerates upwards of one thousand existing species which he refers to *Dryopteris*. These are segregated into ten groups termed subgenera, although most of them are admittedly of generic rank. These groups of species are named *Eudryopteris*, *Stigmatopteris*, *Ctenitis*, *Lastrea* Bory (emended), *Glaphyropteris* Presl, *Steiropteris*, *Cyclosorus* Link (emended), *Leptogramma* J. Sm., *Goniopteris* Presl (emended), and *Meniscium* (Schreber).

The fossil species here described belongs to this author's ninth subgenus, the emended *Goniopteris* of Presl, which I am recognizing as a valid genus, since the data which paleobotany furnishes to recent botany are obscured by the use of generic names that denote composite aggregations of living species like so many of the fern genera in Die Natürlichen Pflanzenfamilien. *Goniopteris* as delimited by Christensen* has about three score, mainly American tropical species, although it is represented in the Old World by at least two species of Africa, Asia and Australia. It is an eminently natural group that has evidently inhabited southeastern North America since the middle Eocene.

The present type belongs with those fossil forms characterized by a single well marked lateral running to the tip of each lateral lobule and these laterals are more often opposite or subopposite than alternate. Each lateral diverges from the midrib of the pinna at an angle of about sixty degrees and gives off, alternately proximad and distad, simple branches, averaging about eight to ten to a side. The basal distal tertiary of one lateral unites with the basal proximal tertiary of the adjacent superior lateral somewhat above the median point between the two laterals. This united vein, termed a ray by Ettingshausen, proceeds in a flexuous course to the marginal sinus, uniting alternately with the distal and proximal tertiaries from the adjacent laterals. In the marginal lobe there are several simple and free tertiaries, usually three or four running to the distal margin and four to six running to the longer because more arched proximal margin. This type of venation is the prevailing type in the specimens collected and is shown in FIG. 3.

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* Christensen, Carl. On a natural classification of the species of *Dryopteris*. Biologiske Arbeijder Tilegnede Eug. Warming. 73–85. N 1911.

The pinnae with the reduced marginal lobulation have an essentially similar venation to that just described. The laterals are more nearly at right angles with the midrib and the tertiaries number ten or eleven, alternating, rather straight pairs; those from adjacent laterals uniting midway between to form a ray that is rather straighter than in the previous case. Each ray terminates at a sinus and there are usually three pairs of free simple veinlets in each lobule, although two or four pairs may be present at times.

In the pinnae that are deeply pinnatifid, the venation, while of the same general plan as in the preceding cases, varies in certain rather remarkable particulars which serve to distinguish the present form from all other previously described fossil species. Only one, two or three tertiaries from each adjacent lateral are concerned in the formation of a principal ray that runs to the sinus of the margin, and one or the other of these tertiaries may fork, the branch uniting with a branch from the next tertiary, the resultant subsidiary vein or ray uniting with the principal ray near the sinus, the two enclosing a laterally elongated rhomboidal areola. The free veinlets are only from one to three terminal pairs; all of the other tertiaries are at least once forked at a greater or less distance above their base, each limb of the fork uniting with a corresponding fork of the next adjacent tertiary, the resulting ray running directly to the margin. This is the *Goniopteris-Aspidii* type of venation of Ettingshausen's Farnkräuter der Jetzwelt (1865).

The venation of this type is still farther complicated by the frequent presence of a very fine subsidiary branch from one or the other forks of a tertiary, and this fine branch runs directly to the margin. This type of venation is shown in FIG. 4.

The principal intermediate type is one in which only a few of the forks of the tertiaries unite with their adjacent fellows from the adjacent tertiaries to form a ray, the majority of the tertiaries being simply once forked with both branches of such forks terminating in the margin.

This handsome and characteristic species is common in the clays of the Yegua formation at Columbia, Louisiana, occurring also in the sandy clays of the Lisbon formation near Newton, Mississippi, but none of the collected material is in fruit. The form and venation are so well marked and distinctive, however, that the species is at once correlated with the rather abundant Tertiary type that, under the name of *Goniopteris*, *Lastrea* or *Phegopteris*, is so characteristic of the fern floras of that time. It is at once distinguished from all of these by the peculiar venation, otherwise it shows the same habit, winged rachis and outline as, for example, *Lastrea stiriaca* Heer* of the European Oligocene, described originally by Unger† as *Polypodites*, referred to *Goniopteris* by Alexander Braun‡ and to *Phegopteris* by Ettingshausen.§

There are at least fifteen known Tertiary species of this general type, most of which are European, although several have been recorded from American localities. Most of the foreign material is somewhat younger than the present species, although two different forms have been described from the middle Bagshot beds of southern England, a nearly homotaxial (Lutetian) horizon.

Several early Eocene species have been recorded in this country from the Rocky Mountain region. In addition to the differences in venation previously referred to, *Lastrea intermedia* Lesquereux‖ from the Denver formation has the pinnae decurrent on the main stipe; *Lastrea Goldiana* Lesquereux¶ from the same horizon has crenulate and deeply divided margins and simple tertiaries; the form from Sand Creek, Colorado, referred to Ettingshausen's Monte Promina species *Lastrea polypodioides***, has a denticulate margin and simple tertiaries. The form from the lower Eocene of Oregon identified by Newberry as *Lastrea Knightiana*†† and commonly referred to the European early Miocene species *Lastrea Fischeri* Heer‡‡ is much like the present species in size and general appearance, but differs in venation. The American material of this last species is rather poor and I doubt very much its identity with the European type. A very widespread Tertiary type of fern liable to be confused with the *Goniopteris* is *Osmunda lignitum* Stur* in which, however, the tertiaries are all always simple, neither anastomosing nor forming interlateral rays.

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* Heer, Fl. Tert. Helv. 1: 31. *pl. 7, 8.* 1855; 3: 151. *pl. 143.* 1859.

† Unger, Chlor. Protog. 121. *pl. 36.* 1847.

‡ Braun, Zeits. Deutsch. Geol. Gesell. 4: 556. 1852.

§ Ettingshausen, Foss. Fl. Bilin. 1: 16. *pl. 2, f. 16–18.* 1866.

‖ Lesquereux, Tertiary Flora, 56. *pl. 4, f. 14.* 1878.

¶ Idem, *f. 13.*

** Idem, 57. *pl. 4, f. 11, 12.*

†† Newberry, Proc. U. S. Nat. Mus. 5: 503. 1882.

‡‡ Heer, Fl. Tert. Helv. 1: 34. *pl. 9, f. 3.* 1855; Lesquereux, Cret. & Tert. Fl. 239. *pl. 50, f. 1, 1a.* 1883; Newberry, Mon. U. S. Geol. Surv. 35: 10. *pl. 48, f. 6.* 1898.

THE JOHNS HOPKINS UNIVERSITY

Explanation of plate 22

GONIOPTERIS CLAIBORNIANA Berry

From the Eocene of Columbia, Louisiana.

FIG. 1. Portion of a pinna, natural size.
FIG. 2. Fragment of a frond, natural size.
FIG. 3. Normal type of venation, × 4.
FIG. 4. Unusual type of venation, × 4.

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* Stur, Jahrb. k. k. Geol. Reichs. 20: 9. *pl.* 2. 1870.

Notes on plants of the southern United States—III

FRANCIS W. PENNELL

As with preceding issues this paper divides itself into two portions. One consists of short notes based upon the writer's field work of 1912 and 1913, recording mostly plants believed new to their respective states. The other and larger portion consists of a revision of the genus *Chamaecrista* in the United States, and for this have been reviewed, besides his own collections, all the material in several of our leading herbaria. In both parts symbols are used; > to indicate in flower; <, in fruit.

MISCELLANEOUS SPECIES

ARISTOLOCHIA LONGIFLORA Engelm. & Gray

Not "*A. longifolia*," as it appears in Coulter, Botany of Western Texas (Contr. U. S. Nat. Herb. 2), and in Small, Flora of the Southeastern United States. Collected near its original station, on dry black loam, Edwards Plateau, northwest of New Braunfels, Comal County, Texas, September 14, 1913, *5435*.

ACTAEA ALBA (L.) Mill.

Deciduous woodland, Catalpa, West Feliciana Parish, Louisiana, August 22, 1912, *4309*. With a large number of northern species, such as *Asplenium pycnocarpon* Spreng., this reaches its southern limit in the loess hills east of the Mississippi River in Louisiana.

CRACCA AMBIGUA (M. A. Curtis) Kuntze

Open long-leaf pine-land, one to two miles north of Abita Springs, St. Tammany Parish, Louisiana, > August 12, 1912, *4136*.

Cracca angustifolia (Featherman) Pennell, comb. nov.

Tephrosia angustifolia Featherman, Bot. Rep. Louisiana 73. 1871.

"Habitat.—Pine barrens near Pontchatoula [Louisiana]." From inquiry at Baton Rouge it seems probable that Featherman's type is not in existence.

Cracca onobrychoides (Nutt.) Kuntze as it occurs in central and western Arkansas and eastern Oklahoma is relatively a stout plant, its stem and leaf-rhachises hirsute with more or less spreading rusty hairs, its leaflets mostly nine to twelve pairs, elliptic-oblong, densely and softly pubescent beneath. The plant here considered, for which is taken up Featherman's name, is more slender, its stem and leaf-rhachises shortly pubescent with appressed or but slightly spreading hairs, giving by their more scattered position the effect of being less rusty, its leaflets six to nine pairs, linear-oblanceolate. This is probably a characteristic plant of the long-leaf pine-land in Louisiana and Mississippi; we have it from Gulfport, Harrison County, Mississippi, < September 8, 1900, *F. E. Lloyd & S. M. Tracy 161*, and from open pine-land, one to two miles north of Abita Springs, St. Tammany Parish, Louisiana, < August 14, 1912, *4189*. Its specific status is here proposed tentatively. Specimens of *C. onobrychoides* collected on prairies in Bowie County, Texas, in 1898, *H. Eggert*,and at Hempstead, Waller County, Texas, *E. Hall 119*, in pubescence and leaf-form show possible first stages of transition toward *C. angustifolia*. The plant needs further field-study.

EYSENHARDTIA TEXANA Scheele

The single species of *Eysenhardtia* occurring through most of central southern Texas is this, based upon Lindheimer's collection at New Braunfels, Texas. It has been confused with the central Mexican *E. polystachya* (Ortega) Sargent (*E. amorphioides* H.B.K.), but is a smaller plant, a shrub rather than a small tree, its leaflets fewer in number, finely puberulent rather than pubescent, its calyx-tube split on posterior side relatively more deeply and its legumes smaller, evidently upcurved, at maturity ascending, not reflexed. Mr. W. E. Safford and the writer are planning a revision of this small but neglected genus. On black calcareous soil, Edwards Plateau, northwest of New Braunfels, Comal County, Texas, > September 14, 1913, *5468*.

ZORNIA DIPHYLLA (L.) Pers.

Sandy soil, one mile east of Aloe, Victoria County, Texas, > September 18, 1913, *5491*. A tropical species, West Indian and

Mexican, extending into southern Arizona, but, so far as I am aware, not before reported from the Gulf States.

LESPEDEZA HIRTA (L.) Ell.

Dry sandy oak-woods west of Sheridan, Colorado County, Texas, collected ≩ September 21, 1913, *5523*.

GALACTIA MARGINALIS Benth. Ann. Wien. Mus. 2: 126. 1838

Perhaps *G. heterophylla* (Gill.) Vail (Bull. Torrey Club 22: 502. 1895), but not *G. heterophylla* A. Gray (Boston Jour. Nat. Hist. 6: 171. 1850).

Sandy soil, one mile east of Aloe, Victoria County, Texas, > September 18, 1913, *5497*.

THE GENUS CHAMAECRISTA MOENCH IN THE UNITED STATES

During my two southern trips especial attention was given to the genus *Chamaecrista* Moench. This genus or, if you will, subgenus of *Cassia* L. has long been known as of particular taxonomic difficulty. As long ago as 1871 Bentham in his revision of *Cassia* emphasized this. Hence it has seemed desirable to see living plants and to study the behavior of the several species.

From the following lists the extent and deficiencies of this field-work will be apparent. I have collected nearly all the species in my course, but, as I did not travel west of central Texas or south into the Florida peninsula, I have seen but six of the thirteen species here recognized.

However, these six include all of the wide-ranging, widely variable sorts, and, as in this genus the characters of diagnostic value preserve well, the main importance of field-study has been to form some appraisement of variation within and between species. Of the geographic subspecies here treated, six in all, the writer has collected three.

Corolla large, exceeding 1 cm in diameter, one petal only moderately longer than remaining four. Stamens 10. Pedicels 1 8, 7 40 mm long.
  Perennials.
    Petiolar gland slender-stalked.
      Leaflets 7 9 mm long, rounded-mucronulate,

glabrous, reddish beneath. Pedicels 30–40 mm. long. Sepals ovate. Legumes 30–40 mm. long, finely appressed-puberulent. 1. *C. Wrightii.*

Leaflets 8–11 mm. long, acute-mucronate, ciliate, green beneath. Pedicels 7–9 mm. long. Sepals lanceolate-attenuate. Legumes 35–40 mm. long, strigose. 2. *C. aristellata.*

Petiolar gland sessile.

Pedicel 1, 25–35 mm. long, exceeding the leaves. Sepals ovate. Stipules ovate. Leaflets strongly ridge-veined. 3. *C. texana.*

Pedicels 1–4, 15–25 mm. long, shorter than the leaves. Sepals lanceolate. Stipules lanceolate-linear. Leaflets not strongly ridge-veined.

Leaflets 4–7 pairs, not ridge-veined, pubescent. Petiolar gland small. Pedicels spreading-pubescent. Legumes 3.5–4 cm. long, pubescent. 4. *C. keyensis.*

Leaflets 12–20 pairs, finely ridge-veined, glabrous. Petiolar glands large, 1–2 mm. long. Pedicels glabrous to finely appressed-puberulent. Legumes 6.5–8.5 cm. long, sparsely finely appressed-puberulent. 5. *C. Deeringiana.*

Annuals.

Petiolar gland depressed, 1–2.5 mm. wide. Pedicels glabrous to more rarely puberulent in lines. Leaflets 10–25 pairs. 6. *C. brachiata.*

Petiolar gland not depressed, 0.07–1.5 mm. wide. Pedicels puberulent to hirsute. Leaflets 6–12(–18) pairs. Species closely related and more or less intergrading.

Leaflets glabrous (occasionally slightly puberulent in *C. fasciculata*). Legumes 3–7 cm. long, 5–7 mm. wide.

Anther-sacs purple. Petiolar gland minute, 0.07–0.2 mm. wide. Leaflets 5–9 pairs. Buds ovate, acute to short-acuminate. Legume relatively long-beaked. Pedicels appressed-pubescent. Plant low. 7. *C. rostrata.*

Anther-sacs yellow (rarely purplish in *C. fasciculata*). Petiolar gland 0.5–1.5 mm. wide. Leaflets 6–12(–18) pairs. Buds lanceolate to ovate-lanceolate, strongly acuminate. Legumes relatively short-beaked.

Pedicels and stems pubescent with incurved hairs. Legumes pubescent with relatively short and appressed hairs. Leaflets 6–12(–15) pairs. Corolla 25–30 mm. wide. 8. *C. fasciculata.*

Pedicels and stems hirsute with spreading hairs. Legumes pubescent with spreading hairs.

Leaflets 9–18 pairs, 15–20 mm. long. Corolla mostly 30–40 mm. wide. Stems stout, erect. 8*a*. *C. fasciculata β.*

Leaflets 6–10 pairs, 8–12 mm. long. Corolla about 25 mm. wide. Stems slender, spreading. 8*b*. *C. fasciculata γ.*

Leaflets pubescent with incurved hairs.

Anther-sacs yellow. Legumes 3–5 cm. long, 5 mm. wide. Plants relatively small-leaved, slender and spreading.

Pedicels and legumes pubescent with incurved hairs. 9. *C. mississippiensis.*

Pedicels and legumes pubescent with spreading hairs. 9*a*. *C. mississippiensis β.*

Anther-sacs purple. Legumes 5–6 cm. long, 4–5 mm. wide. Plant relatively large-leaved, stouter and erect. 10. *C. puberula.*

Corolla small, less than 1 cm. in diameter; one petal much larger than the remaining four. Stamens 5–9. Pedicels 1–2(–3), 2–5 mm. long. Annuals.

Legumes 3–4 mm. wide, 10- to 18-seeded. Leaflets long-ciliate. Odd petal not twice length of others. 11. *C. leptadenia.*

Legumes 4–6 mm. wide, 6- to 9-seeded. Leaflets not ciliate.

Petiolar gland with discoid head much wider than stalk-like base. Corolla with odd petal twice exceeding others. Legumes 7- to 9-seeded, pubescent with incurved (rarely spreading) hairs. Stem pubescent with ascending-incurved, rarely with spreading hairs.

Leaflets glabrous, obtuse, mucronate. Sepals puberulent on midrib. Stipules 5–8 mm. long.

Leaflets 9–18 pairs, 2–4 mm. wide. 12. *C. nictitans.*

Leaflets 15–26 pairs, 1–2 mm. wide. 12*a*. *C. nictitans β.*

Leaflets pubescent with incurved hairs, acutish to acute, more conspicuously mucronate-tipped. Sepals pubescent on midrib. Stipules 8–10 mm. long. 12*b*. *C. nictitans γ.*

Petiolar gland with head but slightly wider than stalk-like base. Corolla with odd petal less than twice exceeding others. Legumes 6- to 7-seeded, hirsute with spreading hairs. Stem, at least above, hirsute with spreading hairs.

Leaflets 15–27 pairs. Stout, erect, mostly hirsute throughout. 13. *C. aspera.*

Leaflets 9–18 pairs. Slender, diffuse, mostly hirsute only above. 13*a*. *C. aspera β.*

1. **Chamaecrista Wrightii** (A. Gray) Pennell, comb. nov.

Cassia (*Chamaecrista*) *Wrightii* A. Gray, Pl. Wright. **2**: 50. Mr 1850.

"Hill-sides, on the Sonoita, near Deserted Rancho, Sonora; Sept. [C. Wright] (1034)." Co-types seen in the herbarium of Columbia University at the New York Botanical Garden and in the herbarium of the Academy of Natural Sciences of Philadelphia.

Perennial. Stem ascending, 3–4 dm. tall, finely puberulent in lines with incurved to appressed hairs. Stipules lanceolate-acuminate, very shortly or not ciliate, 3–4 mm. long. Petioles 3–4 mm. long, slightly puberulent. Petiolar gland single, below proximal leaflets, conspicuously stalked, discoid, 0.15–0.2 mm. wide, dark-brown. Leaflets six to eight pairs, 8–10 mm. long, 2 mm. wide, obliquely ellipsoid-lanceolate, rounded, very shortly mucronulate, glabrous, not ciliate, obscurely nerved. Pedicel one, 30–40 mm. long, sparingly puberulent in lines with incurved hairs. Sepals 7 mm. long, ovate, acute. Petals 10–12 mm. long, the anterior slightly exceeding the laterals. Stamens ten, unequal, two longer; anthers 6–8 mm. long, gradually narrowed above, yellow (?). Legumes 4 cm. long, 5 mm. wide, sparingly finely appressed-puberulent. Seeds eight.

"Hill-sides," northeastern Sonora and southern Arizona.

ARIZONA. Without definite locality, *J. T. Rothrock*, 1874, 4750 ft. alt. (U).

2. **Chamaecrista aristellata** Pennell, sp. nov.

Cassia aristellata A. Gray, manuscript name on sheet here taken as type.

Perennial. Stem ascending, 4 dm. tall, puberulent with incurved hairs and hirsute with interspersed longer spreading hairs. Stipules lanceolate-acuminate, long-ciliate, 5 mm. long. Petioles 3–5 mm. long, hirsute. Petiolar gland single, slightly below proximal leaflets, conspicuously slender-stalked, discoid, 1–1.5 mm. wide. Leaflets six to eight pairs, 10–15 mm. long, 2 mm.

wide, oblique-lanceolate, falcate, acuminate-mucronate on distal side, nearly glabrous, evidently ciliate, evidently nerved. Pedicel one, 7-13 mm. long, appressed-puberulent with incurved hairs. Sepals 10-11 mm. long, lanceolate, acuminate, puberulent. Petals 10 mm. long, the anterior slightly exceeding the lateral. Stamens unequal. Legumes 4 cm. long, 4-4.5 mm. wide, strigose-hirsute, brown. Seeds twelve, 2-2.2 mm. long, oval.

Type, "Texano-Mexicanum," collected in fruit, *Berlandier 2030*, in the herbarium of Columbia University at the New York Botanical Garden.

Apparently differs from *Chamaecrista calycioides* (DC.) Greene of South America, with which it has been confused, by its fewer leaflets and solitary flowers; doubtless, when *C. calycoides* is recollected and fully described, by other characters.

Besides the type collection, the precise locality of which is unrecorded, seen also from Cameron County, Texas, > May 8, 1900, *Vernon Bailey 231*, in the United States National Herbarium.

3. **Chamaecrista texana** (Buckl.) Pennell, comb. nov.

Cassia texana Buckl. Proc. Acad. Nat. Sci. of Phila. **1861**: 452. 1862. "Sandy soil, Bastrop Co., Texas." Type seen in the herbarium of the Academy of Natural Sciences of Philadelphia.

Perennial, from a rhizome. Stems ascending, 2-4 dm. long, puberulent in lines with ascending-incurved hairs. Stipules cordate-triangular, acuminate, slightly ridge-veined, puberulent, ciliate, 3-4 mm. long. Petioles 2-3 mm. long, puberulent with ascending-incurved hairs. Petiolar gland single, below proximal leaflets, sessile, rudimentary or mostly wanting. Leaflets ten to sixteen pairs, crowded, 6-8 mm. long, 1 mm. wide, elliptic-lanceolate, acutish, pubescent, finely ciliate, strongly ridge-veined. Pedicel one, exceeding the subtending leaf, in fruit 30-50 mm. long, puberulent with incurved hairs. Sepals 7-8 mm. long, ovate, acute, finely appressed-puberulent. Petals 10-13 mm. long, the anterior slightly exceeding the laterals. Stamens ten, unequal, one or two longer; anthers 6 mm. long, yellow. Legumes 3-4 cm. long, 5 mm. wide, sparingly finely appressed-pubescent. Seeds eight.

This has been identified as *C. chamaecristoides* and as *C. procumbens.*

C. chamaecristoides (Collad.) Greene, of South America, differs by its longer stouter stems, lanceolate stipules, slightly longer petioles, evident stalked petiolar gland, rounded not winged leaf-rachis (in *C. texana* this is flattened, slightly winged), larger scarcely veined evidently cuspidate leaflets, stouter densely puberulent pedicels shorter than the subtending leaves, and flowers larger, 30–35 mm. in diameter.

C. micrantha Britton ("*C. procumbens*," not L.), of Cuba and the Isle of Pines, differs by its ovate-lanceolate stipules, evident petiolar gland, terete not winged leaf-rachis, shorter scarcely veined usually more puberulent to pubescent leaflets, peduncles becoming but 10–20 mm. long, smaller flowers 15 mm. in diameter, and more puberulent eight- to twelve-seeded legumes.

Dry sandy soil, southern Texas.

TEXAS. Bastrop:* *S. B. Buckley* (A). Cameron: Rudolph, *F. L. Lewton 178* > April 13 (U). Duval: Pena, *G. C. Nealley 117* (P, U). Victoria: Aloe, *F. W. Pennell 5496* > September 18 (P). Webb: Laredo, *Schott 105* > June (Y). Also "De Matamoros a las Nueces," *Berlandier 2427* (A, U, Y).

4. **Chamaecrista keyensis** Pennell, sp. nov.

Perennial. Stems spreading, 1–8 dm. long, densely pubescent with spreading hairs. Stipules lanceolate-acuminate, 4.5–5 mm. long. Petioles 3–6 mm. long, densely spreading-pubescent. Petiolar gland single, toward distal end of petiole, sessile, more or less raised, saucer-shaped. Leaflets four to seven pairs, 7–10 mm. long, 2–4 mm. wide, oblanceolate, mucronate, densely pubescent with somewhat incurved hairs. Pedicels one or two, 15–20 mm. long, pubescent with spreading upcurved hairs. Sepals 8–9 mm. long, lanceolate-acuminate, hirsute. Petals 9–10 mm. long, the anterior but slightly exceeding the laterals. Stamens ten, unequal; anthers 7–8 mm. long, gradually narrowed above, reddish-purple. Legumes 4–4.5 cm. long, 4–5 mm. wide, puberulent with incurved hairs. Seeds twelve, 3 mm. long.

Type, rocky pine woods, Big Pine Key, Monroe County, Florida, collected in flower May 2, 1917, *F. W. Pennell 9553* in the herbarium of the New York Botanical Garden.

The Antillean *C. grammica* (Spreng.) Pollard, with which this has been identified, differs by its appressed pubescence and conspicuously stalked glands.

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* As in preceding lists, one specimen (rarely several) from a county is cited, county-names being arranged alphabetically. For herbaria cited see Bull. Torrey Club **43**: 94. 1916.

Rocky or sandy pine-lands, Florida Keys.

FLORIDA. Monroe: Big Pine Key, *J. K. Small 3785, 3790* < November 17 (Y); No-name Key (U, Y); Ramrod Key (Y).

5. **Chamaecrista Deeringiana** Small & Pennell, sp. nov.

Perennial, from a horizontal rhizome. Stems erect, slender, purple or purplish, 3–6 dm. tall, glabrous or sparingly puberulent above with incurved hairs. Stipules strongly ridge-veined, glabrous, 7–10 mm. long. Petioles 5–8 mm. long, sparingly appressed-puberulent to glabrous. Petiolar gland single, depressed-discoid, 1–1.5 mm. wide, brown. Leaflets 10–20 pairs, 10–20 mm. long, 2–3 mm. wide, lanceolate-linear, acute-mucronate, glabrous, not ciliate, shining, finely ascending ridge-nerved; midrib excentric. Pedicels one to four in a fascicle, 10–20 mm. long, very slender, glabrous to more rarely sparingly puberulent in lines with incurved hairs. Sepals 10–12 mm. long, lanceolate, acuminate, not dilated nor white-margined below, glabrous to finely pulverulent. Petals 14–18 mm. long, anterior slightly exceeding laterals. Stamens ten, unequal, 2 longer; anthers 8–9 mm. long, yellow or reddish. Legumes 6.5–8.5 cm. long, 5 mm. wide, 1 mm. thick, brown, thick-walled (seed-cavities scarcely visible externally), sparingly finely appressed-puberulent to glabrous. Seeds twelve to fifteen, 3.5–4 mm. long, dark purplish-brown.

Type, pine-lands near Silver Palm, Dade County, Florida, collected in flower and fruit June 22, 1915, *J. K. Small, C. A. Mosier & G. K. Small 6454*, in the herbarium of the New York Botanical Garden.

Has been confused with *C. brachiata.*

Pine-lands on Miami limestone, mainland, and on Big Pine Key, southern Florida.

FLORIDA. Dade: Brogdon Hammock; Cocoanut Grove; Cutler; Homestead; Long Prairie; Miami, *N. L. Britton 197* > March 24 (Y); Murden Hammock; Silver Palm; near Timms Hammock, *F. W. Pennell 9540* > April 28 (Y). Monroe: Big Pine Key, *J. K. Small 3781* ≧ November 17, (Y).

6. CHAMAECRISTA BRACHIATA Pollard

Chamaecrista brachiata Pollard, Proc. Biol. Soc. Wash. **15**: 20. Feb. 18, 1902. "Type, No. 330,115, in the United States National Herbarium, collected by Charles L. Pollard and G. N.

Collins at Miami, Dade County, Florida, April 4–7, 1898 (No. 245)." Type seen in the United States National Herbarium.

Annual. Stems erect, 8–12 dm. tall, glabrous or sparingly puberulent above with incurved hairs. Stipules lanceolate-acuminate, glabrous or nearly so, not ciliate, 5–8 mm. long. Petioles 4–8 mm. long, sparingly appressed-puberulent to glabrous. Petiolar gland single, or occasionally two or three and serially placed, closely sessile, effused-discoid to saucer-shaped, 1–2.5 mm. wide, brown. Leaflets ten to twenty-five pairs, 10–20 mm. long, 2–3 mm. wide, linear-lanceolate, acute-mucronate, glabrous, not ciliate, obscurely nerved. Pedicels 1–4 in a fascicle, 10–20 mm. long, glabrous to more rarely sparingly puberulent in lines with incurved hairs. Sepals 10–12 mm. long, lanceolate, acuminate, glabrous or nearly so. Petals 10–18 mm. long, anterior slightly exceeding laterals. Stamens ten, unequal, 2 longer; anthers 7–9 mm. long, reddish to purplish (?). Legumes 6–8 cm. long, 5–5.5 mm. wide, sparingly finely appressed-puberulent. Seeds fifteen to eighteen, 3–3.2 mm. long, dark brown.

Dry pine-land, peninsular Florida (perhaps also in southern Alabama).

FLORIDA. Brevard: Merritt's Island, *A. A. Baldwin 23* < September 1 (A). Dade: Miami, *C. L. Pollard & G. N. Collins 245* < April 4–7 (U, Y). Duval: Jacksonville, *A. H. Curtiss 5156* > August 27 (U, Y). Hillsboro: Tampa, *N. L. Britton & P. Wilson 7* ≷ August 25 (Y). Lake: Eustis, *G. V. Nash 701* > May 1–15 (U, Y). Lee: Pine Island, *S. M. Tracy 7242* > May 14 (P, U, Y). Manatee: Bradentown, *S. M. Tracy 7089* > June 15 (P, U, Y). Marion: Fort King, *Lieut. Alden* (Y). Orange: Clarcona, *M. Meislahn 127* ≷ November 30 (U). Pinellas: Clearwater Key, *S. M. Tracy 6536* > April 21 (U). Polk: Lakeland, *Mrs. T. Meehan* ≷ March (A). Ste. Lucie: Fort Pierce, *A. B. Burgess 724* > April 8–9 (Y). Suwanee: Live Oak, *F. W. Pennell 9799* > May 23 (Y).

(?) ALABAMA. Baldwin: Bay Minette, *J. M. Macfarlane & O. Goertz* > June 15 (P), apparently this, but petiolar gland is quite small.

7. CHAMAECRISTA ROSTRATA Wooton & Standley

Chamaecrista rostrata Wooton & Standley, Contrib. U. S. Nat. Herb. **16**: 135. F 12 1913. "Type in the U. S. National

Herbarium, no. 660032, collected in sandy soil at Logan [New Mexico], October 5, 1910, by Mr. Geo. L. Fisher (no. 93)." Type seen in United States National Herbarium.

Annual. Stem erect, 1–3 dm. tall, branched, finely puberulent over entire surface with ascending-incurved hairs. Stipules lanceolate-attenuate, glabrous or nearly so, slightly ciliate, nerved, 4–6 mm. long. Petioles 2–4 mm. long, finely puberulent with incurved hairs. Petiolar gland single, toward distal end of petiole, sessile, slightly saucer-shaped, 0.07–0.2 mm. wide, brown. Leaflets five to nine pairs, 7–12 mm. long, 2–3 mm. wide, oblong, obtuse, shortly mucronulate, glabrous, scarcely finely ciliolate, paler beneath, faintly nerved. Bracteoles 2–3 mm. long, lanceolate-attenuate. Pedicels one or two in a fascicle, 7–10 mm. long, finely puberulent with incurved hairs. Sepals 7–10 mm. long, ovate-acuminate, puberulent on the midrib. Petals 10–15 mm. long, ovate-acuminate, puberulent on the midrib. Petals 10–15 mm. long, anterior exceeding laterals. Stamens ten, unequal, two longer; anthers 6–8 mm. long, purple. Legumes 3–4.5 cm. long, 4–5 mm. wide, appressed-puberulent with an evident beak, 1–2 mm. long. Seeds six to nine, 3 mm. long.

Sandy soil, Staked Plains of northwestern Texas, southwestern Kansas and eastern New Mexico.

KANSAS. Morton: Richfield, *J. N. Rose 17169* ≷ September 20 (U).

TEXAS. Hemphill: Canadian, *A. H. Howell 87* > July (U). "Staked Plains," *G. W. Holstein* (A).

NEW MEXICO. Quay: Logan, *G. L. Fisher 93* > October 5 (U).

8. CHAMAECRISTA FASCICULATA (Michx.) Greene

Cassia fasciculata Michx. Fl. Bor. Amer. 1: 262. 1803. "*Hab.* in Pensylvania et Virginia." Type not seen nor verified, but description sufficiently indicates this plant.

Chamaecrista fasciculata ["*fascicularis*"] Greene, Pittonia 3: 242. 1897.

Chamaecrista bellula Pollard, Proc. Biol. Soc. Wash. 15: 19. 1902. "Type in the United States National Herbarium, collected by Prof. S. M. Tracy at St. Vincent, Florida, September 9, 1899 (No. 6,326)." Type, collected September 4, 1899, seen in the United States National Herbarium. Perhaps a small-leaved form of the southern Coastal Plain.

Chamaecrista camporum Greene, Pittonia 5: 108. 1903. "Type specimens collected by myself at Monticello, Illinois, 7 August, 1899." Type not seen nor verified, but description evidently of this species.

Cassia Chamaecrista L. (Sp. Pl. 379. 1753. "*Habitat in* Jamaica, Barbados, Virginia") is composite, and should be typified by "Chamae Crista pavonis americana, siliqua multiplici," Breyn. Cent. **66**: *pl. 24*, from Curaçao. This is the species usually known as *Cassia diffusa* DC., an ally of *C. nictitans* L. The Linnaean diagnoses, here, in Hort. Ups. 101, 1748, and in Hort. Cliff. 158, 1737, will apply to this, the phrase "glandula petioli pedicellata" directly excluding our plant.

Annual. Stem erect, 3–9 dm. tall, much branched, puberulent in lines with ascending incurved hairs. Stipules linear-attenuate, glabrous or nearly so, ciliate, many-nerved, 5–10 mm. long. Petioles 5–8 mm. long, puberulent with incurved hairs. Petiolar gland single, near middle or toward distal end of petiole, sessile or nearly so, depressed saucer-shaped, round or slightly oval, 0.5–1.5 mm. wide, dark brown to brown. Leaflets six to twelve (or fifteen) pairs, 10–20 mm. long, 2–5 mm. wide, oblong-linear, obtuse to acute, shortly mucronulate to mucronate, glabrous (rarely very finely puberulent), finely ciliolate, paler beneath, evidently nerved. Bracteoles 3–5 mm. long, linear-attenuate. Pedicels one to six in a fascicle, 10–20 mm. long, finely or sparsely puberulent with incurved (rarely somewhat spreading, then short) hairs. Sepals 9–12 mm. long, lanceolate-acuminate, more or less pubescent on the midrib. Petals 10–17 mm. long, anterior slightly exceeding laterals. Stamens ten, unequal, two longer; anthers 8–10 mm. long, yellow or reddish (especially southwestward). Legumes 4–5 cm. long, 5–5.5 mm. wide, appressed-puberulent or glabrate on the sides, with a beak usually short but reaching 1.5 mm. long. Seeds six to fifteen, 3–3.2 mm. long.

Moist to dry, usually sandy, open places, southeastern Massachusetts to Florida and central Texas, inland to northern Ohio, southern Minnesota and central Kansas. Abundant in many parts of the southeast, especially in the Atlantic Coastal Plain. Northeast of Virginia, rare above the Fall Line, on the Serpentine and occasionally elsewhere in southeastern Pennsylvania.

Variable, and doubtless hybridizes with allied species. Southeastward probably passes into the little-known variety γ southward through the lower Alleghenies and the lower Mississippi valley passes into the very pronounced variety β.

MASSACHUSETTS. Barnstable: Woods Hole, *T. Morong* > August 10 (Y); also Plymouth County.

RHODE ISLAND. Providence: East Providence, *J. F. Collins* > August 26 (U); also Washington County.

CONNECTICUT. Fairfield: Greens Farms, *C. L. Pollard 232* ≷ August 16 (U).

NEW YORK. Nassau: Long Beach, *F. W. Pennell 2312* ≳ October 12 (Y); also Bronx, Richmond, Suffolk and Westchester Counties.

NEW JERSEY. Cape May: Cape May, *F. W. Pennell 2223* > August 4 (U); also Atlantic, Bergen, Camden, Cumberland, Gloucester, Middlesex, Monmouth, Ocean, Passaic and Somerset Counties.

PENNSYLVANIA. Delaware: Williamson School (serpentine). *F. W. Pennell 1640* (Y); also Allegheny, Beaver, Berks, Chester, Dauphin, Huntingdon, Lancaster and Montgomery Counties.

DELAWARE. Sussex: Milton, *A. Commons* > August 17 (A).

MARYLAND. Cecil: Bacon Hill, *F. W. Pennell 1616* > August 4 (Y); also Dorchester and Queen Anne Counties.

VIRGINIA. Princess Anne: Virginia Beach, *T. H. Kearney 2136* < October 6 (U); also Accomac, Fairfax, Hanover, Norfolk and Warren Counties.

WEST VIRGINIA. Jefferson: Harpers Ferry, *Detwiller*, August 6 (A).

NORTH CAROLINA. Buncombe: Biltmore, *Biltmore herbarium 1806* > July 30 (P, U, Y); also Carteret, Cherokee, Craven, Forsyth, Orange, Polk and Rowan Counties.

SOUTH CAROLINA. Orangeburg: Eutawville, *W. W. Eggleston 4980* > September 6 11 (Y); also Aiken and Berkeley Counties.

GEORGIA. Chattooga: Summerville, *C. L. Pollard & W. R. Maxon 446* > August 7 8 (U). Gilmer: Ellijay, *J. K. Small* > August 13-16 (Y). Sumter: *R. M. Harper 1003* > July 5 (U, Y). Whitfield: Dalton, *R. M. Harper 306* > August 10 (U, Y).

FLORIDA. Franklin: St. Vincent (Id.), *S. M. Tracy 6320* < September 4 (U, Y).

ALABAMA. Clay: Talladega Creek, *C. Mohr* > August 1 (U). Dekalb: Mentone, *C. Mohr* ≷ September 2 (U). Jefferson: Birmingham, *C. Schuchert* > October 9 (U, Y). Lee: Auburn,* *F. S. Earle & C. F. Baker* > August 17 (Y).

MISSISSIPPI. Carroll: *E. Smith* (U).

TENNESSEE. Chester: Henderson, *S. M. Bain 54 p.p* > August (Y). Knox: Knoxville, *A. Ruth 2202* > June (Y). Marion: South Pittsburg, *C. L. Pollard & W. R. Maxon 409* > August 3–4 (U, Y). Monroe: Madisonville, *F. L. Scribner* > August (U). Roane: Post Oak Springs, *C. L. Pollard & W. R. Maxon 413* > August 6 (U).

KENTUCKY. On Red River, *R. Peter* > July (Y).

OHIO. Erie: Oxford prairie, *E. L. Moseley* > August 6 (U).

INDIANA. Newton: Roselawn, *H. Hahn* (U).

ILLINOIS. Cook: Calvary,* *F. C. Gates* > August 21 (U); also Vermilion* County.

WISCONSIN: Trempeleau: Trempeleau, *T. J. Hale* (A).

MINNESOTA. Brown: Sleepy Eye, *E. P. Sheldon* > July (U, Y); also Houston and Nicollet Counties.

SOUTH DAKOTA. Minnehaha: Sioux Falls, *Thornber* > August (U).

IOWA. Story: Ames, *L. H. Pammel & C. R. Ball 20* > July 18 (U, Y); also Buchanan, Decatur, Fayette, Hardin and Johnson Counties.

NEBRASKA. Lancaster: Lincoln, *J. G. Smith* > September (C); also Cass County.

MISSOURI. Greene: Springfield, *P. C. Standley 8322* > August 28 (U). Jackson: Courtney, *B. F. Bush 6489* ≷ August 19 (U, Y). Marion: Oakwood, *J. Davis 302* > July 17 (U). Mississippi: Charleston, *O. Kuntze 2862* < September 9 (Y). St. Louis: St. Louis, *N. Riehl 87* > August (Y). Washington: Potosi, *F. Peck* (U).

KANSAS. Geary: Fort Riley, *E. E. Gayle 538* > July 20 (Y); also Douglas, Lyon, Riley and Shawnee Counties.

ARKANSAS. Miller: Texarkana, *A. A. & E. G. Heller 4133* > August 23 (A, U, Y) (leaflets minutely puberulent). Nevada: 4 m. se. of Prescott, *M. P. Hollister 25* > June 17 (U). Pulaski: Little Rock, *H. E. Hasse* (Y).

OKLAHOMA. Creek: Sapulpa, *F. W. Pennell 5392* > September 8 (P). Payne: Stillwater, *F. A. Waugh 358* (U).

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* Approaching *C. fasciculata β*.

LOUISIANA. Caddo: Shreveport, *Gregg* > September 4 (A).

TEXAS. Hays: San Marcos and vicinity, *S. W. Stanfield* (Y). Parker: Weatherford, *S. M. Tracy 8026* > June 3 (P, Y). Travis: Austin, *F. W. Pennell 5430* > September 13 (P) (anthers purple). Walker: Huntsville, *R. A. Dixon 400* > July 9-12 (Y).

8a. CHAMAECRISTA FASCICULATA β

Cassia Chamaecrista robusta Pollard, Bull. Torrey Club 21: 218. 1894. "Type a single specimen in the Columbia College Herbarium collected by Dr. C. W. Short in the mountains of Kentucky." Type seen in the herbarium of Columbia University at the New York Botanical Garden.

Cassia robusta Pollard, *l.c.* 24: 150. 1897.

Chamaecrista robusta Pollard; Heller, Cat. N. A. Pl. 2d ed. 5. 1900.

Stem stouter, 6-15 dm. tall, more or less densely hirsute above with spreading hairs. Stipules lanceolate-attenuate, 10-14 mm. long. Petioles hirsute-pubescent. Leaflets nine to eighteen pairs, 15-20 mm. long, 3-6 mm. wide. Bracteoles 4-6 mm. long. Pedicels 15-25 mm. long, hirsute with spreading hairs. Sepals hirsute on the midrib. Petals 15-20 mm. long. Legumes 5-7 cm. long, 6-7 mm. wide, hirsute-pubescent. Otherwise as in the species.

Moist to dry soil, more frequently in low ground, and most abundant on alluvial soil, southern Ohio to northern Florida, eastern Missouri and Louisiana. Throughout the lower Mississippi valley, mostly in alluvial soil; also pushing up into the valleys of the southern Alleghenies. In southern Louisiana, where I have collected it, seemingly quite distinct from *C. fasciculata*, but study of specimens shows a surprising number of intermediates.

GEORGIA. Clarke: *R. M. Harper* > (Y). Floyd: Rome, *G. McCarthy 311* > July (U).

FLORIDA. Leon: Tallahassee, *N. K. Berg* (Y).

ALABAMA. Baldwin: Tensaw, *S. M. Tracy 8009, 8038* > August 22 (P, U, Y). Barbour: Eufaula, *G. McCarthy* > August (U). Clay: Delta, *C. Mohr* (U). Lee: Auburn, *F. S. & E. S. Earle 30* > September 14 (U, Y).[*]

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[*] Approaching the typical form of the species.

MISSISSIPPI. Franklin: Florence, *E. G. Holt 17* > July 25 (U). Jasper: *S. Deavoms 2942* (U). Noxubee: Prairie Point, *Mrs. P. A. L. Carpenter* ≷ *October* (U). Oktibbeha: Agricultural College, *C. L. Pollard 1276* > August 11–17 (U, Y).

TENNESSEE. Chester: Henderson, *S. M. Bain 54 p.p.* > August (U, Y). Franklin: Cowan, *A. Ruth* > July (U).*

KENTUCKY. Lincoln: Crab Orchard, *C. W. Short* (A). "Mountains of Kentucky," *C. W. Short* (A, Y).

OHIO. "In ditione Miami," *Dr. Frank* (U).

ILLINOIS: Cass: Little Indian, *F. C. Gates* > July 7 (U). Peoria: Peoria, *F. E. McDonald* > September (Y). Richland: *R. Ridgway* (U).

MISSOURI. Polk: Graydon Springs, *P. C. Standley 9895* ≷ September 7 (U). St. Louis: St. Louis, *O. Kuntze 2773* > September 6 (Y).

ARKANSAS. Ouachita: Camden, *A. H. Howell 618* > July 7 (U).

LOUISIANA. Avoyelles: Marksville, *W. L. McAtee 2185* > September 12 (U). West Feliciana: Baines, *F. W. Pennell 4275* > August 21 (P, Y).

8*b*. CHAMAECRISTA FASCICULATA γ

Cassia depressa Pollard, Bull. Torrey Club **22**: 515. *pl. 25*. 1895.

> "Low pine woods, River Junction, Gadsden Co., Florida. G. V. Nash, September 5, 1895 (no. 2571)." Type seen in the herbarium of Columbia University at the New York Botanical Garden.

Chamaecrista depressa Greene, Pittonia **3**: 242. 1897.

Stems spreading-ascending, slender, 1–3 dm. tall, diffusely branched below. Petioles 2–5 mm. long. Petiolar gland .3–1 mm. wide. Leaflets six to ten pairs, 8–12 mm. long, 2–3 mm. wide. Bracteoles 3–4 mm. long. Pedicels 1–3 in a fascicle, hirsute with spreading, and also in part with fine incurved hairs. Sepals 8–10 mm. long, hirsute on the midrib. Legumes spreading-pubescent. Otherwise as in the species. Not satisfactorily known, but certainly not a distinct species.

Open pine-woods, Apalachicola River hills, northwestern Florida.

FLORIDA. Gadsden: Chattahoochee, *S. M. Tracy 3956* >

August 23 (U, Y); River Junction, *A. H. Curtiss 5980* > September 8 (U, Y).

9. CHAMAECRISTA MISSISSIPPIENSIS (Pollard) Pollard

Cassia mississippiensis Pollard, Bull. Torrey Club 21: 219. 1894. "Type in herbarium of Columbia College, collected by Miss K. Skeehan, 1889, at Ocean Springs, Mississippi." Type collected November 7, 1889, seen in the herbarium of Columbia University at the New York Botanical Garden. Several specimens on sheet; these, originally described as "suffruticose," are apparently lateral shoots of a dwarfed diffusely branched plant.

Chamaecrista mississippiensis Pollard; Heller, Cat. N. A. Pl. 2d ed. 5. 1900.

Chamaecrista Tracyi Pollard, Proc. Biol. Soc. Wash. 15: 21. 1902. "Type in the United States National Herbarium, collected by Prof. S. M. Tracy at Koshtaw, Miss., September 15, 1898." Type, *Tracy 4914*, collected October 15, 1898, seen in the United States National Herbarium.

Annual. Stem erect or ascending, 2-6 dm. tall, slender, often diffusely branched at base, finely puberulent with ascending incurved hairs. Stipules lanceolate-attenuate, glabrous or nearly so, ciliate, 4-7 mm. long. Petioles 2-5 mm. long, puberulent with incurved hairs. Petiolar gland single, sessile, depressed saucer-shaped, .3-.6 mm. wide, dark-brown. Leaflets six to fifteen pairs, 5-12 mm. long, 2-3 mm. wide, ellipsoid linear-lanceolate, acutish to acute-mucronate, appressed-puberulent, not ciliate, obscurely nerved. Bracteoles 2-3 mm. long, linear-attenuate. Pedicels one to three in a fascicle, 6-15 mm. long, finely puberulent with incurved hairs. Sepals 5-10 mm. long (in the bud longer than the petals), linear-lanceolate, long-attenuate, appressed-puberulent. Petals 8-15 mm. long, anterior slightly exceeding laterals. Stamens ten, unequal, two longer; anthers 7-9 mm. long, yellow. Legumes 3-5 cm. long, 5 mm. wide, appressed-puberulent. Seeds six to fifteen.

Moist sandy pine-land, southern Mississippi and Louisiana, extending apparently into southern Alabama and southeastern Texas.

ALABAMA. Lee: Auburn, *F. S. Earle & C. F. Baker* > August (U).

MISSISSIPPI. Copiah: *L. R. Gibbes* > August (Y). Harrison: Biloxi, *F. W. Pennell 4378* > August 28 (P). Jackson: Scranton, *S. M. Tracy 4436* > August 29 (U).

LOUISIANA. Caddo: Shreveport, *F. S. Earle* > June (Y). Plaquemines: Breton Island, *S. M. Tracy & F. E. Lloyd 198 p.p.* > August 17 (P). Rapides: Alexandria, *C. R. Ball 540 p.p.* > June 3 (U, Y). St. Landry: Opelousas, *C. Mohr* > March 15 (U). St. Tammany: Abita Springs, *F. W. Pennell 4228* > August 16 (P, Y).

TEXAS. Harris: La Porte, *G. L. Fisher 643* > August 15 (U).

9*a*. CHAMAECRISTA MISSISSIPPIENSIS β

Chamaecrista littoralis Pollard, Proc. Biol. Soc. Wash. 15: 20. 1902. "Type, No. 371,572 in the United States National Herbarium, collected by Prof. S. M. Tracy and Prof. F. E. Lloyd on Breton Island, La., August 17, 1900 (No. 198)." Type seen in the herbarium of the United States National Museum.

Stems mostly stouter, 4–8 dm. tall, erect. Leaflets 7–15 mm. long. Pedicels hirsute with spreading, sometimes also with shorter incurved hairs. Legumes hirsute-pubescent. Otherwise as in the species.

Sandy soil, in the Coastal Plain, mostly near the Gulf coast, on dunes and in pine-land, western Florida to eastern Texas.

FLORIDA. Wakulla: St. Marks, *F. Rugel* > June (Y).

ALABAMA. Mobile: Hollanders Island, *F. W. Pennell 4506* > September 2 (P, Y); Theodore, *F. W. Pennell 4444* > August 30 (P, Y).

MISSISSIPPI. Clarke: Shubuta, *C. Schuchert* > October 11 (U). Harrison: Cat Id., *F. E. Lloyd & S. M. Tracy 183* ≷ August 26 (U, Y). Jackson: Horn Id., *S. M. Tracy 6927* > July 14 (U). Wayne: Waynesboro, *C. L. Pollard 1217* > October 8–9 (U, Y).

LOUISIANA. Calcasieu: Lake Charles, *S. M. Tracy 3957* > August 7 (U). Plaquemines: Breton Island, *F. E. Lloyd & S. M. Tracy 198 p.p.* < August 17 (U, Y.).

TEXAS. San Augustine: San Augustine, *G. L. Crocket* (U).

10. CHAMAECRISTA PUBERULA Greene

Chamaecrista puberula Greene, Pittonia 5: 134. 1903. "On Galveston Island [Texas], 23 Sept. 1901 [S. M. Tracy]." Co-type of Tracy, *7797*, seen in the herbarium of the New York Botanical Garden.

Annual. Stem erect, 4–8 dm. tall, puberulent with ascending-incurved hairs. Stipules lanceolate-acuminate, nerved, puberulent, finely ciliate, 4–5 mm. long. Petioles 3–6 mm. long, puberulent with incurved hairs. Petiolar gland single, short-pediceled to sessile, discoid to slightly saucer-shaped, 0.5–1 mm. wide, dark-brown. Leaflets ten to fifteen pairs, 10–18 mm. long, 2–4 mm. wide, linear-lanceolate, acutish to acute-mucronate, densely puberulent, not ciliate, midrib evident, elsewhere obscurely nerved. Bracteoles 1–2 mm. long, lanceolate-ovate. Pedicels one to three in a fascicle, 5–20 mm. long, puberulent with incurved hairs. Sepals 6–8 mm. long (in the bud shorter than the petals), ovate-lanceolate, acute to short-acuminate, pubescent. Petals 10–15 mm. long, anterior slightly exceeding laterals. Stamens 10, unequal, 2 longer; anthers 4–5 mm. long, deep purple. Legumes 5–6 cm. long, 4–5 mm. wide, appressed-puberulent. Seeds eight to fourteen, 3.7–4 mm. long.

Moist to dry sandy soil, southern Texas.

TEXAS. Colorado: Sheridan, *F. W. Pennell 5538* > September 21 (P, Y). Dewitt: Cuero, *A. H. Howell 252* > July 7 (U). Galveston: Galveston, *F. W. Pennell 5574* > September 23 (P, Y). Lavaca: Hallettsville, *G. L. Fisher 126* ≷ August (U). Nueces: Kings Ranch, *V. Bailey 251* > May 10 (U). Robertson: Hearne, *F. W. Pennell 5418* > September 11 (P, Y). Webb: Laredo, *A. Schott 110* > June (Y). Wharton: Pierce, *S. M. Tracy 7796* > September 16 (U, Y), anther-sacs yellowish or reddish.

11. CHAMAECRISTA LEPTADENIA (Greenman) Cockerell

Cassia leptadenia Greenman, Proc. Amer. Acad. 41: 238. 1905. "48 km. east of El Paso, May to October, 1849, *Chas. Wright*, no. 154 (hb. Gray)." Co-type seen in the United States National Herbarium.

Chamaecrista leptadenia Cockerell, Muhlenbergia 4: 68. 1908.

Annual. Stem erect, slender, 1–5 dm. tall, sparingly branched, puberulent in lines with incurved to spreading hairs. Stipules linear-attenuate, glabrous or nearly so, conspicuously ciliate, nerved, 5–7 mm. long. Petioles 2–5 mm. long, puberulent with incurved hairs. Petiolar gland single, stalked, discoid, 0.2–0.3 mm. wide, nearly black, stalk brown. Leaflets twelve to sixteen pairs, 8–12 mm. long, 1–2 mm. wide, oblong-linear, acutish, mucronate-tipped, glabrous, strongly ciliate, obscurely nerved. Bracteoles 1–1.7 mm. long, lanceolate. Pedicels one or two in a fascicle, 3–5 mm. long, appressed-puberulent. Sepals 4–5 mm. long, lanceolate, acuminate, hirsute. Petals 3–6 mm. long, anterior twice exceeding laterals. Stamens unequal; anthers 2 mm. long, yellow (?). Legumes 3–4.2 cm. long, 3–4 mm. wide, appressed-puberulent. Seeds ten to eighteen, 3 mm. long, very thin, light-brown.

Dry soil, western Texas to southeastern Arizona.

TEXAS. El Paso: *C. Wright 154* (U). Presidio: Chenates region, *G. C. Nealley 541* (U).

NEW MEXICO. Dona Ana: Organ Mountains, *E. O. Wooton 435* < September 1 (Y). Luna: Floridas, *A. I. Mulford 1038a* > August 2 (Y).

ARIZONA. Cochise: Bowie; Chiricahua Mts., *J. C. Blumer 2086* > August 30 (U); Fort Huachuca; Tucson. Pima: Santa Rita Mountains, *D. Griffiths & J. J. Thornber 212* (U, Y).

12. CHAMAECRISTA NICTITANS (L.) Moench

Cassia nictitans L. Sp. Pl. 380. 1753. "*Habitat in* Virginia." Typified by L. Hort. Cliff. 497. *pl. 36*, 1737, where an excellent description and figure are given.

Cassia procumbens L. *l.c.* 380. 1853. "*Habitat in* Indiis." Based wholly upon "Cassia americana procumbens, herbacea, mimosae foliis, floribus parvis, siliquis angustis, planis," A. J. A[mmann], Comm. Petrop. **12**: 238–242 (cited erroneously by Linnaeus as "Comm. petrop. t. 11"). This is fully described and is unquestionably *Chamaecrista nictitans* (L.) Moench. The type-locality is stated "circa Philadelphiam urbem in Pensylvania, Americae septentrionalis provincia, sitam." There appears to have been no specimen in the Linnean herbarium in 1753, and the species is not checked by Linnaeus until his third list in 1767. The West Indian plant known until recently by this name has been described by Dr.

Britton as *Chamaecrista micrantha* Britton, Bull. Torrey Club 43: 463. O 20 1916.

Chamaecrista nictitans Moench, Meth. 272. 1794.

Nictitella amena Raf. Sylv. Tellur. 128. 1838. New name for *Cassia nictitans* L., type of the genus *Nictitella* Raf.

Cassia Chamaecrista nictitans Kuntze, Rev. Gen. Pl. 1: 169. 1891.

Chamaecrista nictitans commixta Pollard & Maxon, Proc. Biol. Soc. Wash. 14: 163. 1901. "Type in U. S. National Herbarium, No. 357,069, collected by Charles L. Pollard and William R. Maxon in alluvial soil along the New River at Quinnimont, W. Va., August 21, 1899 (No. 31)." Type seen in the United States National Herbarium.

Cassia nictitans commixta Millsp. W. Va. Geol. Surv. 5: 283. 1913.

Annual. Stem erect, 1–4 dm. tall, much branched, puberulent with incurved hairs. Stipules lanceolate-attenuate, glabrous or nearly so, ciliate, nerved, 5–8 mm. long. Petioles 4–9 mm. long, puberulent with incurved hairs. Petiolar gland single, shortly below proximal leaflets, stalked, discoid or nearly so, 0.3–0.8 mm. wide, dark-brown. Leaflets nine to eighteen pairs, 7–15 mm. long, 2–4 mm. wide, oblong-linear, obtuse, mucronate, glabrous, not ciliate, paler beneath, obscurely nerved. Bracteoles 1.5–2 mm. long, lanceolate. Pedicels one to two or three in a fascicle, 2–4 mm. long, appressed-puberulent. Sepals 3–4 mm. long, lanceolate, acuminate, puberulent on the midrib. Petals 3–8 mm. long, anterior twice exceeding laterals. Stamens unequal, five; anthers 2 mm. long, pinkish. Legumes 2.5–4 cm. long, 4–6 mm. wide, appressed-pubescent. Seeds six to nine, 3 mm. long, thick, dark-brown.

Sandy soil, or sterile soil, frequently along roadsides, probably near the borders of its range introduced, southern Vermont and Rhode Island, to eastern Kansas, Georgia and Texas.

VERMONT. Windham: Vernon, *A. J. Grout* > August 6 (U).

RHODE ISLAND. Providence: Elmwood, J. F. Collins > August 25 (U).

CONNECTICUT. Fairfield: Bridgeport, *E. H. Eames* < September 14 (U).

NEW YORK. Westchester: Mount Kisco, *F. W. Pennell 6713* < September 26 (Y); also Albany, Bronx, Orange, Putnam, Queens, Rensselaer, Richmond and Suffolk Counties.

New Jersey. Bergen: Alpine, *F. W. Pennell 6532* < September 12 (Y); also Atlantic, Burlington, Camden, Cape May, Gloucester, Middlesex, Morris, Ocean and Sussex Counties.

Pennsylvania. Chester: Unionville, *F. W. Pennell 992* < October 3 (A); also Beaver, Berks, Bucks, Delaware, Lancaster, Lehigh, Montgomery, Northampton and Philadelphia Counties.

Delaware. Sussex: Milton, *A. Commons* > August 17 (A); also Kent and Newcastle Counties.

Maryland. Queen Anne: *E. G. Vanatta* > August 29 (A).

Virginia. Augusta: Staunton, *W. A. Murrill* < September 5 (Y); also Botetourt, Hanover, and Princess Anne Counties.

West Virginia. Fayette: Quinnimont, *C. L. Pollard & W. R. Maxon 31, 39* ≷ August 21 (U, Y); also Ritchie County.

North Carolina. Buncombe: Biltmore, *Biltmore Herbarium 181b* > August 14, < September 28 (P, U, Y); also Cherokee, Craven, Haywood, Iredell, Orange, Polk and Swain Counties. Pasquotank: Elizabeth City, *F. L. J. Boettcher 291* > August 26 (U, Y) (leaflets but 6–7 mm. long and pubescence of upper part of stem spreading; perhaps a coastal form).

South Carolina. Pickens: Six Mile Creek, *H. D. House 3078* < October 22 (U).

Georgia. Chattooga: Summerville, *C. L. Pollard & W. R. Maxon 435* > August 7–8 (U). DeKalb: Stone Mountain, *C. L. Pollard & W. R. Maxon 463* > August 10–12 (U). Whitfield: Dalton, *R. M. Harper 395* > August 10 (U, Y).

Alabama. Clay: Elders, *C. Mohr* > July 30 (U). Dekalb: Mentone, *C. Mohr* > September 1 (U). Lee: Auburn, *F. S. Earle* > September 12 (Y).

Mississippi. Claiborne: Martin, *J. W. White 2944* > September 12 (U). Oktibbeha: Starkville, *S. M. Tracy 1422* < September 1 (U, Y).

Tennessee. Knox: Knoxville, *A. Ruth 291* ≷ August (Y).

Kentucky. Bell: Pine Mt., *T. H. Kearney 496* < September (U); also Lyon County.

Ohio. Fairfield: Lancaster, *W. A. Kellermann* > August 18 (U).

Indiana. Lake: Tolleston, *V. H. Chase 298* < September 23 (A).

ILLINOIS. Henderson: Oquawka, *H. N. Patterson* (U).

MISSOURI. Barry: Eagle Rock, *B. F. Bush 44* < September 28 (U, Y); also Greene, St. Louis and Scott Counties.

KANSAS. Cherokee: *A. S. Hitchcock 668* (U, Y).

ARKANSAS. Benton: *E. N. Plank* (Y). Pulaski: Little Rock, *H. E. Hasse* > August 26 (Y).

OKLAHOMA. Le Flore: "9 m. west of Fort Smith," *J. M. Bigelow* (U).

LOUISIANA. Rapides: Alexandria, *J. Hale* (Y). West Feliciana: Catalpa, *F. W. Pennell 4278* > August 21 (P, Y).

TEXAS. Burnet: Marble Falls, *E. N. Plank* > August 10 (Y).

12*a*. CHAMAECRISTA NICTITANS β

Cassia multipinnata Pollard, Bull. Torrey Bot. Club **22**: 515. *pl. 250.* 1895. No type indicated, and first specimen listed, Curtiss 712 (cited as "512"), is composite, consisting of plant described and in part of *Chamaecrista aspera*. Second specimen cited, "Near Jacksonville, A. H. Curtiss, North American Plants . . . second distribution, No. 5157, September 15, and October 27, 1894," is taken as the type. Type seen in the herbarium of the United States National Museum.

Cassia multipinnata Nashii Pollard, *l.c.* 515. 1895. "Collected in low pine woods, River Junction, Gadsden Co., Florida, by Mr. Nash, Sept. 5, 1895 (2577)." Type seen in the herbarium of the New York Botanical Garden.

Chamaecrista multipinnata Greene, Pittonia 3: 243. 1897.

Stem 1-5 dm. tall. Stipules linear-attenuate. Leaflets fifteen to twenty-six pairs, 1-2 mm. wide. Legumes 4-5 mm. wide. Seeds six to twelve. Otherwise as in the species.

Sandy soil, in the Coastal Plain, especially in the pine-land, South Carolina to southern Mississippi. In the long-leaf pine-land replacing the species, of which it may be no more than an ecological form.

SOUTH CAROLINA. Aiken: Aiken, *H. W. Ravenel* (U).

GEORGIA. Bibb: Macon, *J. M. Green* (A). Brooks: Quitman, *R. M. Harper 1632* > September 13 (U, Y). Burke: *M. H. Hopkins 19* > September 9 (Y). Sumter: Americus, *S. M. Tracy 3958* > August 20 (U).

FLORIDA. Alachua: Gainesville, *H. S. Fawcett* < November (P). Duval: Jacksonville, *A. H. Curtiss 5157* > September 15 (U). Gadsden: River Junction, *G. V. Nash 2577* > September 5 (A, Y). Leon: Tallahassee, *G. V. Nash 2403* > August 12 (U, Y). Wakulla: St. Marks, *F. Rugel 199* > September (U).

ALABAMA. Baldwin: Daphne, *C. Mohr* > August 18 (U), Cullman: Ryans Creek, *C. Mohr* < August 6 (U). Lee: Auburn. *C. F. Baker 31* < October 10 (Y). Mobile: Theodore, *F. W. Pennell 4445* > August 30 (P, Y).

MISSISSIPPI. Clarke: Shubita, *C. Schuchert* < October 11 (U). Harrison: Pass Christian, *F. W. Pennell 4362* > August 27 (P, Y). Jackson: Ocean Springs, *S. M. Tracy 4434* > August 20 (U). Simpson: Saratoga, *S. M. Tracy 8505* > August 6 (P, U, Y).

12*b*. CHAMAECRISTA NICTITANS γ

Cassia aspera Mohrii Pollard, Bull. Torrey Club **24**: 151. Mar. 30, 1897. "Type in the herbarium of the U. S. Geol. Surv. of Alabama, collected in Mobile in 1878 by Dr. Mohr." Probable co-type, lacking statement of date, seen in the United States National Herbarium.

Chamaecrista aspera Mohrii Pollard; Heller, Cat. N. Am. Pl. 2d ed. 5. Nov. 10, 1900.

Stem 3–5 dm. tall, densely puberulent to spreading-pubescent. Stipules more ciliate, 8–10 mm. long. Leaflets 18–23 pairs, 9–12 mm. long, 2 mm. wide, narrowly oblong-linear, acute, strongly mucronate-tipped, pubescent with incurved hairs. Sepals hirsute-pubescent, especially on midrib. Legumes more hirsute. Otherwise as in the species.

Sandy soil in the Coastal Plain, southern Georgia to Louisiana and southern Arkansas. Insufficiently known, but probably not specifically distinct.

GEORGIA. Decatur: *E. A. Smith* (U).

ALABAMA. Mobile: Mobile, *C. Mohr* (U).

ARKANSAS. Miller: Texarkana, *A. A. & E. G. Heller 4134* > August 23 (A, U, Y).

LOUISIANA. Caddo: Shreveport, *Gregg* > September 6 (U). Rapides: Alexandria, *J. Hale* (Y).

13. CHAMAECRISTA ASPERA (Muhl.) Greene

Cassia aspera Muhl.; Ell. Bot. S. C. & Ga. 1: 474. 1821. "On Eding's island near Beaufort [South Carolina], common." Type not seen nor verified, but description sufficiently indicates this plant.

Nictitella aspera Raf. Sylv. Tell. 128. 1838.

Chamaecrista aspera Greene, Pittonia 3: 243. 1897.

Annual. Stem erect, 3–7 dm. tall, branched, strigose-hirsute with spreading hairs, below mostly also puberulent with some shorter incurved hairs. Stipules lanceolate-attenuate, conspicuously ciliate, nerved, 8–11 mm. long. Petioles 2–5 mm. long, hirsute, as well as the rachis, with spreading hairs. Petiolar gland single, shortly below proximal leaflets, stalked, truncate, scarcely wider than the stalk, 0.15–0.25 mm. wide, brown or dark-brown. Leaflets fifteen to twenty-seven pairs, 8–15 mm. long, 1.5–2 mm. wide, narrowly oblong-linear, acute, strongly mucronate, glabrous, not ciliate, slightly glaucous beneath, obscurely nerved. Bracteoles 1.5–2 mm. long, lanceolate. Pedicels one to two or three in a fascicle, 3–4 mm. long, appressed-puberulent. Sepals 3–5 mm. long, lanceolate, acuminate, strigose-hirsute on the midrib. Petals 3–7 mm. long, anterior nearly or twice exceeding laterals. Stamens unequal, seven to nine; anthers 2 mm. long, "yellow." Legumes 1.5–2.5 cm. long, 4–5 mm. wide, strigose-hirsute. Seeds three to eight, 2.5 mm. long, 2 mm. wide, thick.

Sandy soil, hammocks, fields or in pine-land, peninsular Florida, extending northward along the Atlantic coast to southern South Carolina.

FLORIDA. Dade: Miami, *N. L. Britton 456* > April 4 (Y). Duval: Jacksonville, *A. H. Curtiss 5158* > September 19 (U, Y). Hillsboro: Tampa, *N. L. Britton & P. Wilson 82* > August 25 (Y). Lake: Eustis, *G. V. Nash 1717* > August 16–25 (A, U, Y). Lee: Alva, *A. S. Hitchcock 56* (U, Y). Manatee: Perico Id., *S. M. Tracy 7244* > May 14 (U, Y). Monroe: Key West, *Blodgett* (U, Y). Orange: Clarcona, *M. Meislahn 35* > September 19 (U). Pinellas: St. Petersburg, *Mrs. C. C. Deam 2751* > September 18 (U, Y).

13*a*. CHAMAECRISTA ASPERA β

Cassia Simpsoni Pollard, Bull. Torrey Club 21: 221. 1894. "Florida—Big Pine Key, Simpson (May, 1891), No. 174.

Type, three specimens in the National Herbarium, collected by Mr. J. H. Simpson." Type seen in the United States National Herbarium.

Chamaecrista Simpsoni Pollard; Heller, Cat. N. A. Pl. 2d ed. 5. 1900.

Stem spreading, 1–3 dm. tall, diffusely branched, puberulent with incurved hairs below or throughout, hirsute with longer hairs only above or rarely throughout. Leaflets 9–19 pairs, 5–11 mm. long. Pedicels 2–3 mm. long.—Otherwise as in the species, with which it seems to completely intergrade. Pine-lands, extreme southern Florida.

FLORIDA. Dade: Cocoanut Grove, *N. L. Britton 285* ≳ March 26 (Y); Fort Dallas; Homestead; Miami. Monroe: Big Pine Key, *F. W. Pennell 9554* ≳ May 2 (Y); Boca Chica, *F. W. Pennell 9613* > May 15 (Y); Cudjoe, *F. W. Pennell 9556* ≳ May 5 (Y); Key West; Little Pine Key; No Name Key.

INDEX TO AMERICAN BOTANICAL LITERATURE

1916-1917

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the word America being used in the broadest sense.

Reviews, and papers that relate exclusively to forestry, agriculture, horticulture, manufactured products of vegetable origin, or laboratory methods are not included, and no attempt is made to index the literature of bacteriology. An occasional exception is made in favor of some paper appearing in an American periodical which is devoted wholly to botany. Reprints are not mentioned unless they differ from the original in some important particular. If users of the Index will call the attention of the editor to errors or omissions, their kindness will be appreciated.

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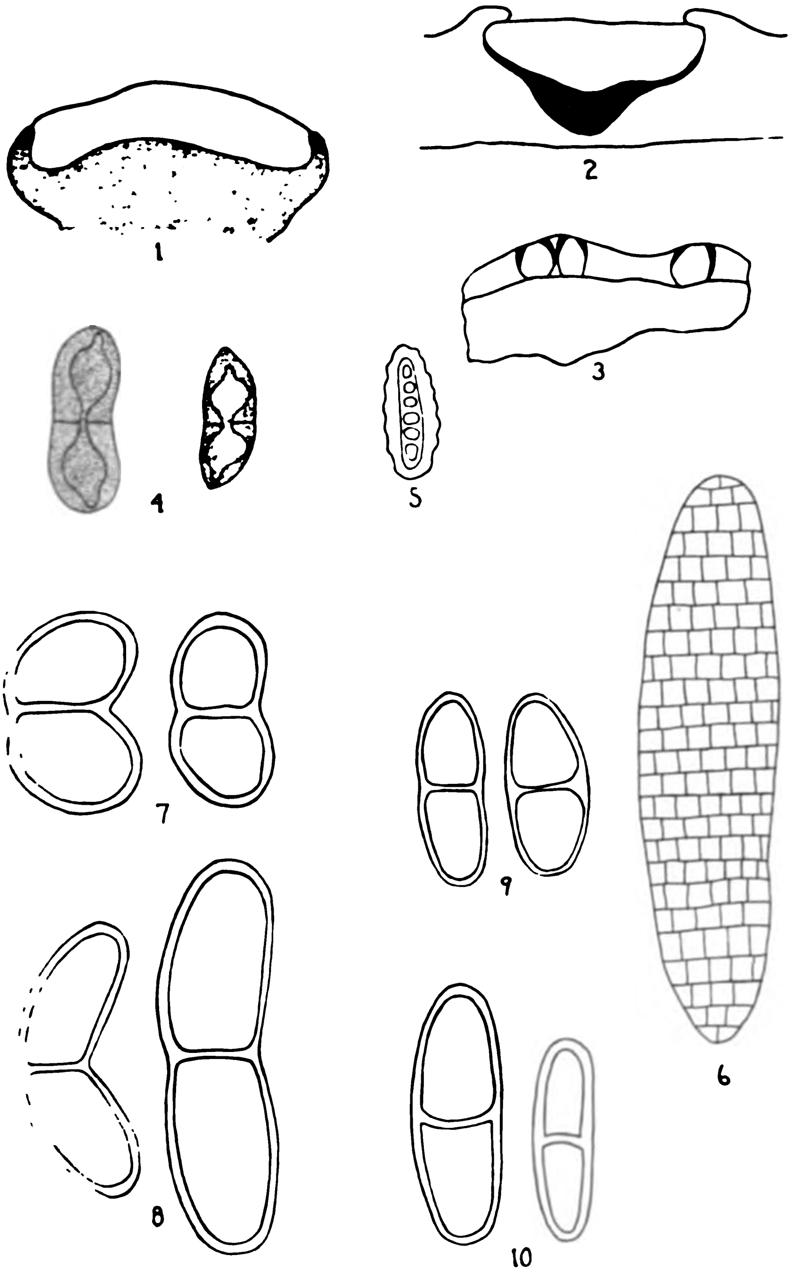

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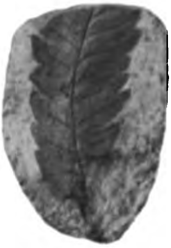
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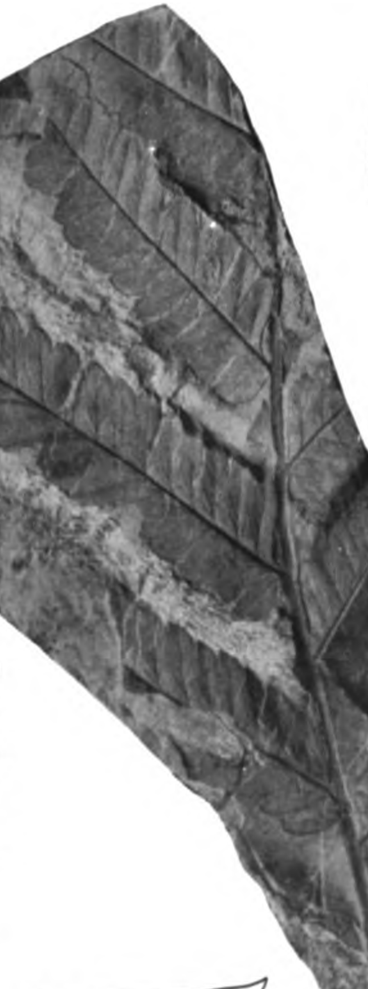
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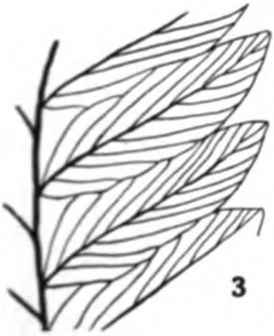
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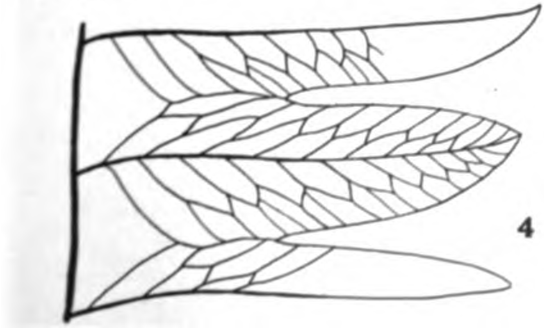
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GONIOPTERIS CLAIBORNIANA Berry

Vol. 44 No. 8

BULLETIN
OF THE
TORREY BOTANICAL CLUB

AUGUST, 1917

The ferns and flowering plants of Nantucket—XVIII

EUGENE P. BICKNELL

APPENDIX

*BOTRYCHIUM TENEBROSUM A. A. Eaton.

Three plants deep in the thickets of Herrecator Swamp in Squam, July 8, 1912. They grew in a dryish spot in a bed of moss (*Catherinea angustata* Brid.) with a group of six adder's tongue ferns and a single plant of *Botrychium virginianum*, all within the space of not more than one square foot. The plants were small, 5–12 cm. high, and bore sporophylls with mature sporanges. Their identity has been determined by Miss Margaret Slosson at the New York Botanical Garden. Mrs. Britton has given me the name of the moss with which they grew.

*BOTRYCHIUM DISSECTUM Spreng.

Polpis, August 20, 1910, herbarium of Miss Grace Brown Gardner; Thorn lot, a single plant in damp half shade, June 26, 1912.

*BOTRYCHIUM VIRGINIANUM (L.) Sw.

Squam, July 8, 1912, a single plant associated with *Botrychium tenebrosum*. Divisions of sterile segment 17–19 mm. in length; fertile segment rudimentary.

*POLYPODIUM VULGARE L.

Reported from Nantucket by Dr. J. A. Cushman (see Rhodora 13: 105. 1911). No other one of our common eastern plants that have been found on Nantucket was less to be expected there than

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[The BULLETIN for July (44: 321–368, *pl.* 21, 22) was issued July 14, 1917.]

this rock-loving and woodland fern. The manner of its occurrence is therefore worthy of attention. Its discoverer, Miss Grace Brown Gardner, wrote me in August, 1910, that it had been found that month among the Miacomet pines not far from where the heather grows, "only one small plant with less than a dozen fronds, and only one fruiting one." Miss Gardner's description of the locality enabled me two summers later, on July 5, 1912, to find the station without any difficulty. There were then two plants about six inches apart, one having five, the other four fronds, none of them bearing sori. The plants were in deep shade and grew within the rim of a circular depression in the ground about three and a half feet in diameter and a foot in depth where, long before, a tree may have been removed or an excavation made for planting one. Similar hollows are to be seen elsewhere among the pines, which are said to have been set out in 1876. The ferns grew in a bed of moss, *Rhynchostegium serrulatum* (Hedw.) Jaeg., determined by Mr. R. S. Williams, and overarching them were two fronds of *Dryopteris spinulosa.* Needless to say all were left undisturbed. Notwithstanding the very natural surroundings the evidence is clear that the spot had not been unknown to the spade, and some connection may be suspected between this and the presence of the polypody. Like the heather it may have come in with the pines, possibly from Europe, or it may have been long ago planted there, perhaps by some tourist plant lover visiting the heather.

*PHEGOPTERIS PHEGOPTERIS (L.) Underw.

Phegopteris polypodioides Fée.

Dense hillside thicket north of the Wauwinet road towards Abram's Point. Here, on June 9, 1912, it grew in great profusion thickly covering the ground throughout a space of fully twenty-five by fifteen feet and fruiting abundantly.

LYCOPODIUM OBSCURUM L.

The var. *dendroideum* (Michx.) D. C. Eaton was collected west of Capaum Pond, May 31, 1909, the strobiles beginning to wither. Mrs. Flynn has sent me a specimen collected west of the town August 13, 1911, bearing fifteen well-developed spikes.

*ISOËTES TUCKERMANI A. Br.?

Professor W. A. Setchell has very kindly forwarded to me specimens of an *Isoëtes*, from the herbarium of the University of California, that were collected by him in company with Professor W. J. V. Osterhout, in Gibb's Pond, Nantucket, in the summer of 1894. I quote from Professor Setchell's letter of transmittal: "We found the *Isoëtes* when we were bathing in the pond. It grew in water so deep that we could not reach down for it but grubbed it out with our toes and collected it as it floated to the surface. My impression is that it formed a regular zone at a depth of four or five feet. I particularly remember that we were in water up to about the chin while we were collecting it. None of it grew in the more shallow margins. I may add that the bottom of the pond was thickly covered with the *Isoëtes* in the zone in which it grew."

The plant is the smallest and most delicate form of *Isoëtes* that I have ever examined. Although it is quite probable that it is correctly referred to *I. Tuckermani* it is scarcely well enough matured to permit of conclusive determination. Mrs. Britton, who has examined the gynospores under high power, gives me the following particulars: "Size, 415 μ, not pitted, slightly roughened"; Miss Margaret Slosson, who has studied the specimens, reports as follows: "Impossible to determine by the macrospores as they are too immature to show their characters; but the spots 'scattered, 1-few-celled' on the sporangia show distinctly and indicate *I. Tuckermani*."

*PINUS STROBUS L.

A single tree was discovered July 9, 1912, among an extensive growth of pitch pines less than a half mile south of the County Fair grounds. It was about ten feet in height and was formed of several clustered trunks, actually erect branches that had replaced an original trunk, the stoutest one measuring seventeen and one half inches in circumference near the base; the lowest branches lay firmly along the ground, spreading fully thirty-five feet in their widest extent. The undisturbed surroundings scarcely allow it to be supposed that this tree was deliberately planted, and how it came to Nantucket remains a mystery. A chance introduction by seed seems quite possible, perhaps through the agency of some bird that, like the crossbills or the Canada nuthatch, feeds on the seeds of conifers.

Note.—The Labrador or jack pine (***Pinus Banksiana*** Lamb.), which has been planted at Wauwinet, has been mistakenly attributed to Nantucket as a native tree (see Rhodora **18**: 241–242. 1916).

*SAGITTARIA RIGIDA Pursh.

Collected in Polpis, August 20, 1899, in flower and fruit, by Mrs. Nellie F. Flynn, who has kindly sent me a specimen from her herbarium for examination.

*ECHINOCHLOA MURICATA (Michx.) Fernald.

This well-defined segregate from *E. crusgalli*, recently restored to recognition by Professor Fernald (Rhodora **17**: 105–107, 1915), belongs to the flora of Nantucket although its exact status there remains to be determined. I have collected it near the town, and have seen a specimen in Miss Gardner's herbarium. It is locally common on Martha's Vineyard.

PANICUM VIRGATUM L.

A well-marked smaller form of this species, described in Part II of this paper (Bull. Torrey Club **35**: 184. 1908), answers perfectly to the description of *Panicum virgatum cubense* Griseb. in Hitchcock & Chase, North American Species of *Panicum* (Contr. U. S. Nat. Herb. **15**: 92. 1910). This form seems not to have been reported from east of Connecticut.

*PANICUM TSUGETORUM Nash.

Common in exposed sandy places and among open growths of oak and pine. The Nantucket plant is not the typical form described by Nash, but the stiffer and stouter more pubescent plant defined by Hitchcock & Chase. On Nantucket it is much more common than *P. columbianum*. Examples of each in which their differences are well expressed appear like perfectly separable species, but perplexing intermediates are so frequent that a broad treatment could scarcely present them as being unequivocally distinct. Occasional densely tufted very pubescent forms with smaller closely flowered panicles of more numerous and smaller spikelets suggest hybridization with *P. oricola*. Slender and narrow-leaved forms with small panicles and spikelets seem to be quite intermediate with *P. meridionale* Ashe.

PANICUM COLUMBIANUM Scribn.

The var. *thinium* Hitchc. & Chase is recorded from Nantucket in their North American Species of *Panicum* (p. 249), on the basis of specimens collected by me in 1899 and 1904. I have myself no clear conception of this plant. The specimens cited, and others since collected more or less similar, suggest aberrant forms of *P. meridionale* or of *P. albemarlense.*

*PANICUM ORICOLA Hitchc. & Chase.
*PANICUM ALBEMARLENSE Ashe.

Earlier in this paper these grasses were included in *P. meridionale*. Transition between all three is, I think, perfectly obvious, but there is, nevertheless, the paramount fact that each in its true development upholds a well-defined type recognizable unmistakably everywhere in the field. We do not know that hybridization may not have been at work releasing the connecting forms but, however this may be, it would seem that a frank recognition of what nature has been careful to produce on an extensive scale must accept these closely related grasses as being essentially distinct.

P. oricola is more especially confined to sterile sandy tracts often along shores. In damper soils among taller vegetation it develops elongated leafy culms and shows a marked departure from its usual habit. Certain examples difficult to assign have the appearance of being hybrids with *P. meridionale*, and occasional stout forms even suggest involvement with *P. tsugetorum*.

P. meridionale is the most common and generally distributed of the three and abounds amid the low herbage of the plains and commons all over the island. A very small and delicate form of this species, if such it be, collected in dryish places along thickets in Tom Never's Swamp is especially to be remarked. *P. meridionale*, like all of its local group, appears everywhere to be perfectly constant in its character of obviously pubescent spikelets. In this small form the spikelets are either quite lucid and glabrous or with a very few mostly basal or marginal hairs; the panicles are very small and few-flowered and, with the culms, less puberulent than in the species, or essentially glabrous.

P. albemarlense more than the others passes into ambiguous forms appearing to intergrade variously with *P. meridionale*, but characteristic examples stand well apart.

A series of specimens of all three species has been verified by Professor Hitchcock and Mrs. Chase.

*PANICUM AUBURNAE Ashe.

Collected in Squam, at Surfside and in the pine barrens. Specimens have been determined by Professor Hitchcock and Mrs. Chase. Compared with a series from Long Island the Nantucket plant is less copiously velvety-villous, the nodes not so conspicuously white bearded and the culms less elongate and declined. Professor Hitchcock writes me that these Nantucket and Long Island specimens are the first he has seen from the coastal region north of Virginia. Certain less typical examples from Nantucket seem to approach *P. albemarlense.*

*PANICUM IMPLICATUM Scribn.

In low grounds, apparently scarce. Little Neck, June 22, 1910; Thorn lot, June 17, 1910.

PANICUM HUACHUCAE Ashe.

The var. *sylvicola* Hitchc. & Chase, of a lax and slender form, was collected on a shaded bank in Squam, June 8, 1912.

*PANICUM SCOPARIUM Lam.

Collected by Miss Grace Brown Gardner in Polpis, August 24, 1915; excellent specimens are preserved in Miss Gardner's herbarium. A most interesting addition to the Nantucket flora, connecting the Martha's Vineyard and Cape Cod stations where alone this southern grass was previously known in New England.

*ARRHENATHERUM ELATIUS (L.) Beauv.

Sparingly in a field below the Cliff, June 15, 1910, and in Madequet, far from any cultivated ground, June 17, 1911.

FESTUCA OVINA L.

Examples of the var. *hispidula* Hack., having the lemmas rather densely hirsute, are occasionally met with in and near the town.

FESTUCA RUBRA L.

Not infrequent examples, doubtless introduced, differ from the native plant by their blue-glaucous coloring and stiffer leaves, as well as in other less obvious characters, and appear to be referable to the var. *glaucodea* Piper, according to Piper's description (Contr. U. S. Nat. Herb. **10**: 22. 1906). I am inclined to think that our native salt marsh grass commonly referred to *F. rubra* is distinct from the European plant and should stand as *Festuca glabra* Spreng.

*FESTUCA ELATIOR L.

F. arundinacea Schreb.

Very typical examples of the tall fescue grass were collected June 18, 1910, by a fence along the railroad on Washington Street, the larger panicles 47 cm. in length, the spikes 15–17 mm. long, and leaves as broad as 1.5 cm. Also found on Easton Street, June 3, 1911.

Although the distinction between the tall fescue and the meadow fescue (*F. pratensis* Huds.) is not now commonly recognized, their differential characters are too pronounced to be justly disregarded. These differences are well brought out in the descriptions of both species in the first edition of Gray's Manual.

BROMUS HORDACEUS L.

Forms having the spikelets glabrous or nearly so are doubtless to be referred to the var. *leptostachys* (Pers.) Beck (var. *glabrescens* [Coss.] Shear). It is abundant by roadsides near the railroad in the suburbs of the town.

BROMUS COMMUTATUS Schrad.

Brant Point Road; above the Cliff; Island View Farm; coming into flower early in June. *Bromus racemosus* L., included earlier in this list, should doubtless be referred to a small form of *B. commutatus*, if the two are held to be distinct.

*SCIRPUS OLNEYI Gray.

Sparingly in a salt marsh along a thicket near Abram's Point, not yet fully mature June 2, 1909.

*SCIRPUS NOVAE-ANGLIAE Britton.

Abundant along the inlet to Coskaty Pond, June 12, 1911; a well-established colony at Squam Pond varying in extent in different years; spikes appearing June 10, 1911, not yet fully developed June 20, 1910; in full flower July 4, 1912. Also collected in Squam by Miss Gardner, September 2, 1913, then in mature fruit.

*SCIRPUS ERIOPHORUM Michx.

Miss Gardner's herbarium contains a perfectly typical specimen of this *Scirpus* collected in Polpis, September 6, 1915.

*CAREX LAEVIVAGINATA (Kükenth.) Mackenzie.

This well defined sedge, recently interpreted by Mr. Mackenzie (Britton & Brown, Ill. Fl. ed. 2, 1: 371. 1913) and later announced from New England by Professor Fernald (Rhodora 17: 231–232. 6 Ja 1916), is frequent in wet places on Nantucket where I have collected it in Quaise, June 11, 1908, in open ground; in Polpis thickets, June 15, 1908, and along the creeks, June 28, 1912. In Nantucket specimens the perigynia are mostly 5 mm. in length (4.5–5.5 mm.), those of *C. stipata* Muhl. averaging 4.5 mm. (4–5 mm.). The smooth sheaths, in contrast with the cross-wrinkled sheaths of *C. stipata*, are an obvious distinguishing feature and seemingly a perfectly constant one.

*CAREX LUPULIFORMIS Sartwell.

Bog hole near Eatfire, July 11, 1915. Not sufficiently mature to show conclusively the always distinctive form of the ripe achenia, but the character of the narrow pistillate spikes and the very long-peduncled staminate ones are unmistakable.

*CAREX MONILE Tuckerm.

In boggy places west of Trot's Swamp, June 1, 1910, and on July 3, 1912, then fully mature.

*CAREX CRINITA Lam.

Several tufts along a brooklet flowing into Squam Pond, June 20, 1910; one cluster by a pool near the shore in Quaise, June 9, 1911.

CAREX DEBILIS Michx.

This sedge, although not before reported, I think, from north of New Jersey, is widespread and locally common on Nantucket. Conversely the closely related species *C. flexuosa*, which it might be expected would be common there, appears to be one of the island's rarer Carices. Recorded previously under the name *C. tenuis* Rudge.

*CAREX FLEXUOSA Muhl.

Carex tenuis Rudge.

Collected in the Thorn lot, June 27, 1910. It is scarcely to be doubted that it occurs elsewhere on the island.

*CAREX CONOIDEA Schk.

Damp field in Shawkemo not far from the harbor shore, well scattered through the grassy low growth about one spot, June 4, 1909.

*CAREX PRAIREA Dewey.

Abundant in Shawaukemmo meadow where it appears to be strictly localized on Nantucket. In early bloom June 8, 1911; in full flower July 1, 1912.

*CAREX DIANDRA Schrank.

With the above and much more mature, July 1, 1912, the achenia falling.

*CAREX CEPHALOIDEA Dewey.

A single tuft by a thicket at Shawaukemmo farm; spikes immature June 4, 1909; fully developed July 1, 1912. It is locally common on Chappaquiddick Island.

CAREX STRAMINEA Willd.

A recent enlightening study of this species by Mr. Kenneth K. Mackenzie (Bull. Torrey Club **42**: 603-608. 1915) has made it clear that, as commonly accepted, it has embraced two distinct species, one of them being the *Carex tenera* of Dewey (*C. straminea* var. *tenera* Boott). *Carex straminea echinodes* of Part III of this paper (Bull. Torrey Club **35**: 496. 1908) should now be referred to *C. tenera*. An additional locality where it is rather numerous is in low grounds westward from Trot's Swamp. It has not been met with on the eastern side of the island. True *Carex straminea*, specimens having been determined by Mr. Mackenzie, proves to be a not uncommon sedge of Nantucket inhabiting low grounds.

CAREX ALATA Torr.

Maxcy's Pond, one tuft, June 17, 1910; also in a bog with *Carex Walteriana* Bailey and near Monomoy, June 28, 1912.

*COMMELINA COMMUNIS L.

Occasional in waste places, and by streetsides in the town.

JUNCUS BUFONIUS L.

The var. *halophilus* Buchenau & Fernald grows in abundance about ponds at the south shore of the island.

*ALLIUM CANADENSE L.

At three widely separated localities: border of Trot's Swamp, two stations; Shawkemo, along a low bank back of the shore; Siasconset. Heads very small, June 2, 1909; in full flower June 22, 1910.

*ALLIUM VINEALE L.

Among the long grass in a neglected yard on Main Street, June 13, 1911, the stems bearing immature spear-like heads.

*ORNITHOGALUM UMBELLATUM L.

Waste lots and old lawns in the town and occasional in the suburbs; field below the Cliff; field south of the town. In full flower May 30, 1909; still in bloom June 5, 1910, 1911.

*NARCISSUS POETICUS L.

Along a thicket at Trot's Swamp near the site of a long-abandoned farm, July, 1912; a scattered colony in a basin-like depression in the dry commons southwest of the town, associated with *Baptisia tinctoria* (L.) R. Br., *Artemisia caudata* Michx., *Hudsonia ericoides* L. and the bearberry, the flowers withered June 5, 1911.

*IRIS PSEUDACORUS L.

About Lily Pond where, I was told, it had been collected by Mrs. Lydia M. Folger as long ago as 1889. A large colony along a ditch east of Union Street, 1909 (Mrs. Nellie F. Flynn).

*SISYRINCHIUM ANGUSTIFOLIUM Mill.

Shawkemo, two plants together; Quaise, sparingly at one station; near Grove Lane; west of Long Pond at the station for *Argentina anserina* (L.) Rydb. In full flower June 4, 1909, and June 9, 1911.

*PERAMIUM PUBESCENS (Willd.) MacM.

Epipactis pubescens A. A. Eaton.

Collected on Tuckernuck, September 7, 1914, by Miss Grace Brown Gardner. It occurs also on Martha's Vineyard, but has not as yet been found on Nantucket Island.

*CORALLORHIZA MACULATA Raf.

Recorded from Nantucket by Dr. Joseph A. Cushman (see Rhodora **13**: 105. 1911). A specimen in full flower was sent to me by Miss Gardner with the information that it was collected

August 18, 1910, in pine woods near Miacomet Pond, where a large number of plants were found.

PERSICARIA HARTWRIGHTII (Gray) Greene.

Polygonum Hartwrightii Gray.

Muddy shore of Squam Pond, June 20, 1910, not yet showing any signs of flowering. Leaves oblong-lanceolate becoming strigillose, many of them marked medially with a dark chevron; ocreae developing a foliaceous and spreading fringed margin. Growing sparingly in the water near the shore was a weaker glabrate form with floating upper leaves and unmargined ocreae.

*CHENOPODIUM GLAUCUM L.

A specimen sent to me by Mrs. Flynn was collected near the railroad in the town August 7, 1911, in full flower.

*SALSOLA PESTIFER A. Nelson.

Salsola Tragus L.

Not observed before 1912 when two plants were found by street sides in the town, and a small colony in an abandoned chicken paddock at Surfside. Just in flower July 9.

*TETRAGONIA EXPANSA Murr.

Prospect Hill rubbish dump, September 15, 1913, in flower. Specimen communicated by Miss Gardner.

*SILENE CONICA L.

Well established and in full flower and fruit in the corner of a field north of the town June 16, 1911; a single plant on a bank by the railroad beyond Orange Street, July 18, 1910.

*SILENE NOCTIFLORA L.

One plant in full flower in a weedy yard on Union Street, June 20, 1910. Collected by Mrs. Flynn June 28, 1895.

*SILENE ANGLICA L.

Specimens of this catchfly from Nantucket and reports of its occurrence there have reached me from several sources. It does not appear, however, that it has been found outside of a small garden and yard on Main Street where, quite probably, it had once been cultivated. I saw it there, evidently spontaneous, and scattered here and there like a garden weed.

*VACCARIA VACCARIA (L.) Britton.

Vaccaria vulgaris Host.

In abundance in a grain field at Quidnet, July 21, 1910, in full flower, Miss Gardner; weedy yard on North Water Street, June 27, 1910, first flowers; waste ground at Surfside.

*DIANTHUS PLUMARIUS L.

Scattered through the grass of a bank on Grove Lane, doubtless an escape from an adjoining cemetery; in full flower June 21, 1910. On Chappaquiddick Island it is thoroughly established at one locality, forming an uneven turf of dense cushion-like tufts.

*AQUILEGIA VULGARIS L.

A waif in waste ground on Prospect Hill, September 22, 1913, herbarium of Miss Grace Brown Gardner.

*THALICTRUM DASYCARPUM Fisch. & Lall.

Little Neck, in low grounds, two clusters, the tallest plants fully six feet high, just in bloom June 22, 1910; bank near Watt's Run, in full flower July 11, 1912, much less mature than *T. revolutum* DC. which grew near by. Apparently not before reported from New England. Specimens collected are perfectly typical and agree closely with authentic material from the western states.

*PAPAVER SOMNIFERUM L.

Rubbish dump on Prospect Hill, August 13, 1915, in full flower, herbarium of Miss Grace Brown Gardner; waste place, 1895, Mrs. Nellie F. Flynn.

*PAPAVER RHOEAS L.

At the same locality as the above July 14, 1915, in full flower, herbarium of Miss Grace Brown Gardner.

*ARGEMONE MEXICANA L.

West Silver Street, July 15, 1910, with immature fruit, herbarium of Miss Grace Brown Gardner.

LEPIDIUM NEGLECTUM Thellung.

This little-recognized peppergrass, earlier recorded in this list, but with a mark of interrogation, may now be definitely added to the Nantucket flora. A single plant in flower and fruit was found in a weedy yard on North Water Street, June 7, 1910, and four well-fruited plants in an old chicken paddock at Surfside, July 9, 1912.

•Sinapis alba L.

Collected by Miss Gardner in waste ground at Prospect Hill in flower and fruit, July 16, 1916.

•Brassica oleracea L.

A few plants by weedy street sides at two places, 1910, 1911.

•Barbarea Barbarea (L.) MacM.

Barbarea vulgaris R. Br.

A group of plants on Sea Street in flower and fruit, June 16, 1910; border of Trot's Swamp, June 22, 1910.

•Camelina sativa (L.) Crantz.

Collected by Miss Gardner in flower and fruit at Prospect Hill, July 16, 1916.

•Radicula sylvestris (L.) Druce.

Polpis roadside, July 19, 1909; rubbish dump west of the town, August 21, 1913, in full flower at both dates, collected by Miss Grace Brown Gardner.

•Neslia paniculata (L.) Desv.

Waste yard, North Water Street, July 27, 1911, one plant bearing a long fruiting raceme and a few terminal flowers.

•Arabidopsis Thaliana (L.) Britton.

Sisymbrium Thalianum J. Gay.

Yard on West Silver Street, May 31, 1912, in flower and fruit; collected by Miss Grace Brown Gardner.

•Koniga maritima (L.) R. Br.

Alyssum maritimum Lam.

Old wharf, 1894, Mrs. M. P. Robinson; an escape, 1895, Mrs. Nellie F. Flynn (*fide* F. G. Floyd).

•Hesperis matronalis L.

An occasional roadside weed in the town; waste place towards Monomoy, in full flower June 3, 1911.

•Sedum telephioides Michx.

No introduced native plant that has been found on Nantucket affords greater cause for surprise from its occurrence there than this species. It was collected by Miss Gardner in a waste yard in the town. The specimen sent me bears date September, 1914, and is in full flower. It has been carefully compared at the New York Botanical Garden, in conjunction with Dr. Britton, and agrees so closely with authentic material in the herbarium that although we feel some slight hesitancy in pronouncing it identical there seem to be no reasonable grounds for doubting its equivalency. The species has been grown in botanical gardens but is not in general cultivation, and how or when it came to be transported to Nantucket is hard to conjecture. Miss Gardner writes me that "it has grown for years in a neglected yard on Milk street and is occasionally found in old yards and lanes in the south part of the town."

*HAMAMELIS VIRGINIANA L.

"Thicket opposite Bloomingdale," 1896, Mr. L. L. Dame, reported in a letter to Mrs. Owen, *fide* Mr. F. G. Floyd. Mr. Dame's determination of this unmistakable shrub cannot be questioned and, although it has not been met with on Nantucket by any other collector, it is perfectly at home in parts of Martha's Vineyard. The only representative on Nantucket of the family Hamamelidaceae.

*FRAGARIA TERRAE-NOVAE Rydb.

In the herbarium of the New York Botanical Garden is a specimen of this strawberry determined by Dr. Rydberg, which was collected at Siasconset June 8, 1900, by Miss M. A. Day (Plants of Nantucket, No. 9).

*POTENTILLA RECTA L.

Collected by Miss Gardner in waste ground on Prospect Hill, August 23, 1913, in flower and fruit. Mrs. Flynn writes me that she found it "quite abundant in the Catholic Cemetery where it was probably introduced in grass seed."

*FILIPENDULA ULMARIA (L.) Maxim.

Found at Consue Spring, July 9, 1912, freshly in flower and forming part of a tall weedy growth, some of the plants being nearly six feet in height.

ROSA.

By a sort of routine and acquiescent view all the wild roses of Nantucket that are not *Rosa carolina* L. might seem to pass readily enough to *Rosa virginiana* Mill. Nevertheless it may easily be discovered that there are some palpable misfits with that species, variable though it be. Certain specimens indeed clearly raise the question whether there may not be other species, at present undistinguished from *R. virginiana*, that belong to the island's flora. The final answer may well be an affirmative one, yet it can scarcely precede a more critical study of the subject than has yet been attempted.

One of these nonconforming roses has already been discussed in Part VIII of this paper (Bull. Torrey Club **38**: 450–451. 1911). Another, collected at Wauwinet and in Shawkemo, is somewhat intermediate between *R. virginiana* and *R. carolina;* Dr. Rydberg, who has examined the specimens, surmises that it may be a hybrid.

Yet another rose, collected only in Tom Never's Swamp, differs from *R. virginiana* by densely bristly new shoots, straight and slender infrastipular spines, more obovate leaflets of a livelier green color, shining on the upper surface and bright green beneath, the common rachis often bearing numerous stalked glands, the flowers solitary or few together. Dr. Rydberg has determined this to be the *Rosa obovata* of Rafinesque (*R. laxa* Lindley), a rose that has missed recognition by later botanists and the exact status of which remains to be determined. On Nantucket it was collected June 15, 1911, not then in flower; it was subsequently found on Long Beach, Long Island, in full bloom. On both occasions it was not doubted that it was a different rose from *R. virginiana* which grew close about it, its affinity appearing to be rather with *R. nitida* Willd.

Another ambiguous Nantucket rose, collected on Coatue, agrees with the preceding in its densely bristly stems, but differs in its strong and broad-based hooked prickles, more glandular hypanthium and narrower leaflets. It is such a plant as might be predicted from a crossing of *R. obovata* with *R. virginiana*, and, quite possibly, such a parentage may have been its actual origin.

*LATHYRUS LATIFOLIUS L.

Waste ground, Prospect Hill, August 3, 1915, Miss Grace Brown Gardner; a cluster in full flower in the south part of the town June 23, 1910.

VICIA ANGUSTIFOLIA (L.) Reichard.

Plants are frequent whose leaf characters correspond to those of the var. *segetalis* (Thuillier) Koch.

*VICIA CRACCA L.

Scattered in tangled masses through a field east of Island Home, June 28, 1912; abundant and in full flower in a sandy field at Surfside, July 9, 1912.

*ACER NEGUNDO L.

An estray from cultivation. Collected by Mrs. Flynn in full flower May 5, 1906.

*ABUTILON THEOPHRASTI Medic.

Rubbish dump on Prospect Hill, collected by Miss Gardner in full flower September 9, 1914.

*VIOLA TRICOLOR L.

Scattered sparingly through the grass of a lawn on North Water Street, in full flower, June 20, 1910.

*LYTHRUM SALICARIA L.

In August, 1916, Miss Gardner sent me fresh specimens of the typical form of this plant from a field near No-bottom Pond, and also a specimen of var. *tomentosum* (Mill.) DC. from a field near Lily Pond, both collected by Mrs. G. A. Spear. The typical plant had not previously been found on Nantucket.

So different of aspect are these two plants, and so well defined are comparative differences between them that the eye hesitates to accept them as being of no greater diversity than mere variants of a single species. The Nantucket var. *tomentosum* is not exceptional, for when I have met with it elsewhere its differences from true *L. Salicaria* were equally pronounced. It may be significant of different soil preferences of the two plants that var. *tomentosum* appears to be the only one that is found along the sandy south shore of Long Island where, though scarce, it is widely scattered, while the locally abundant plant of heavy wet soils along the Hudson, and inland in boggy places among the hills, is the typical form.

*OENOTHERA RUBESCENS Bartlett.

Little is known of this *Oenothera* recently described by Dr. H. H. Bartlett from plants raised from Nantucket seeds (Cybele Columbiana 1: 50. 1914). It is probable that the living plant also has been collected on Nantucket. Specimens, not yet mature, of a form found there that I was unable to place were submitted to Dr. Bartlett, who wrote me in regard to them under date of November 28, 1914: "They appear to be my n. sp. *Oe. rubescens*, to be published shortly. The seeds came to me from Professor George F. Atkinson, at Ithaca, and were originally collected on Nantucket by Miss Grace B. Gardner. I drew up my description this summer from living plants."

*OENOTHERA.

Miss Gardner has sent me specimens of an *Oenothera* collected by her on Nantucket, August 24, 1915, which differs strikingly from any form I have myself seen there. It is in full flower and early fruit and is notable from the perfectly glabrous axis of the inflorescence, glabrous capsules and small early deciduous subtending bracts; the hypanthium is slender and glabrous, becoming over 3 cm. long, and the tips of the calyx lobes are hispid with translucent diverging hairs. The leaves subtending the branches, these being the only ones seen, are thin, oblong- to ovate-lanceolate on slender petioles and thinly short-pubescent, their margins distantly glandular-denticulate; the branches are thinly roughish-pubescent toward the base, the longer hairs flexuous and arising from minute red papillae.

*HEDERA HELIX L.

The European ivy flourishes on Nantucket and has become locally well-established away from cultivated grounds. On Sunset Hill it may be seen running through the grass in dense masses and clothing old fence posts and tree trunks with all the vigor and luxuriance of our native Virginia creeper. Flowers profusely in September.

*ERICA VAGANS L.

Miss Alice O. Albertson has sent me flowering specimens of this European heath which were collected by Miss Eleanor Owen "among pine trees north of Head of Hummock Pond," August 10, 1915. The specimens sent are two small sprays, each bearing three clusters of flowers.

Much has been written about the three heaths common in the British Isles that have long been known to grow on Nantucket, but it seems never to have been suspected that a fourth species belongs to the wild flora of the island. How long it has grown there and by what agency it became established may never be known, but it is to be hoped that its station will be rediscovered and careful observations made to ascertain if there be not in the surroundings some hint as to its origin there.

Mrs. Owen has told us that in days now long past persistent efforts were made to increase the heather on Nantucket, and that seeds of both purple and white heather had been sown on the commons. Presumably these seeds came from Great Britain and the white heather referred to was the white-flowered form of the Scotch heather or ling. *Erica vagans*, sometimes called the Cornish heath, is a species more especially of the Mediterranean region, and is of local occurrence only as far north as the British Isles. It has occasionally been offered here in tradesmen's catalogues.

*CUSCUTA EPITHYMUM Murr.

Specimens in full flower have been sent to me by Miss Gardner, collected by her in Squam August 19, 1915, growing on *Laciniaria scariosa* (Willd.) Hill.

Note.—In a paper by the late Professor John H. Sears (see Rhodora **10**: 43. 1908) is a list of plants of more southern distribution that occur in Essex County, Massachusetts, with mention of their nearest known stations south of Boston. Included in this list is *Cuscuta arvensis* Beyrich, its nearest station south being given as Nantucket.

GALEOPSIS TETRAHIT L.

Mrs. Flynn has sent me a specimen of this species collected in a waste place west of the town August 14, 1911, a much branched and well-seeded plant bearing some late flowers. Both this species and *Galeopsis Ladanum* L. have already been mentioned in this list, having been admitted into Mrs. Owen's catalogue. No other evidence has appeared respecting the latter as a Nantucket plant.

*CLINOPODIUM VULGARE L.

Satureia vulgaris Fritsch.

Miss Alice O. Albertson has sent some flowering specimens of this mint collected by her September 16, 1916, in a field opposite the Franklin Fountain where it was first discovered by Professor

John W. Harshberger in August, 1915. It had not before been known from Nantucket and we must suppose it to be an introduction more or less recent.

*MENTHA GLABRATA (Benth.) Rydb.

Mentha canadensis var. *glabrata* Benth.

Collected by Miss Gardner at Wauwinet in full flower July 24, 1915. Plant evidently bright green, leaves narrow, attenuate at base, rather distantly low-serrate, glabrate. On Nantucket *Mentha canadensis* L. shows a marked tendency towards an unusual degree of pubescence, and extreme examples even closely approach the more northern var. *lanata* Piper. The glabrate plant is thus at contrast with the ordinary Nantucket form in a very marked degree. At Alexandria Bay on the St. Lawrence, where I once met with it, it appeared so unlike *M. canadensis* that I did not at first suspect its close relationship. Its unmistakably different and pleasanter fragrance seemed especially noteworthy.

*SOLANUM VILLOSUM (Mill.) Lam.

Mrs. Flynn has sent me an excellent specimen of this plant in flower and early fruit collected by her in a yard at Milk and Main Streets, September 4, 1901. The plant is over 6 dm. high, openly branched, with thin sinuate-dentate leaves, and is more or less villous-pubescent throughout, especially on the younger parts, and evidently somewhat viscid; the inflorescence is racemose rather than sub-corymbose as in *S. peregrinum* Bicknell, the calyx lobes membranous, only slightly if at all venose, and triangular acute; the flowers appear to be somewhat larger than those of *S. nigrum* L., their anthers 1.5 1.75 mm. long on glabrous filaments. It agrees closely with many authentic specimens of *S. villosum* from Colorado and Idaho to Washington and California. I am not aware that it has ever been reported from New England.

*ASTER ERICOIDES L.

In Miss Gardner's herbarium I found a specimen of this aster from Tuckernuck, collected September 14, 1914. It is a somewhat pubescent form approaching the var. *villosus* T. & G. and agreeing rather closely with examples from Chappaquiddick Island where, as elsewhere on Martha's Vineyard, it is a scarce plant.

Mechanics of movement in Drosera rotundifolia*

HENRY D. HOOKER, JR.

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I. INTRODUCTION

Plant growth is defined technically as any permanent change of shape or size produced by the activity of the plant (*cf.* Jost, '13, p. 339; Pfeffer, '06, p. 1). The movements of *Drosera* tentacles, being reactions to stimuli, are determined by the activity of the *Drosera* plant. Moreover, bending is accompanied by a permanent elongation of the convex side of the tentacle and unbending by a corresponding increase in the length of the concave side (Hooker '16). These movements are therefore phenomena of growth. The term "growth" obviously includes a number of processes, which may be determined by changes in the amount of protoplasm, cell-wall material or osmotically active substances.

II. EXPERIMENTAL DATA

1. OSMOTIC CONCENTRATION

In order to obtain a more detailed knowledge of the growth which brings about the movement of *Drosera* tentacles, the concentration of osmotically active material dissolved in their cells was measured by plasmolysis. For this purpose solutions of potassium nitrate and glucose were prepared. The osmotic concentration of plant cells may be compared with the concentrations of these substances in terms of their relative osmotic values. Consequently osmotic concentrations will be measured in atmospheres as follows:

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* Contribution from the Osborn Botanical Laboratory.

Atmospheres	Solutions of KNO_3 in percentages	Solutions of glucose in percentages
5	1.43	3.85
6	1.71	4.62
7	2.00	5.40
8	2.29	6.17
9	2.57	6.95
10	2.86	7.71
11	3.14	8.48
12	3.43	9.25
13	3.71	10.02
14	4.00	10.80
15	4.29	11.58

Tentacles of the *Drosera* were removed from the leaf with forceps, placed in prepared solutions, mounted and examined under the high power of the microscope. Plasmolysis was found to be most readily detected in slightly pigmented cells, and whenever possible tentacles with stalks composed of such cells were selected. In case aggregation occurred, the first traces of plasmolysis were much more difficult to make out. Tentacles were treated and examined when straight; just after bending in response to a tactile stimulus; when fully bent; during unbending; and when again straight. The first procedure was to place tentacles in each of the prepared potassium nitrate solutions and to examine them for traces of plasmolysis. The results obtained by this general orientation were repeated and verified by numerous subsequent experiments both with potassium nitrate and with glucose solutions. The data given with glucose solutions were practically identical throughout with the results furnished by the potassium nitrate solutions. The final data given below are expressed in terms of the most concentrated solution that failed to plasmolyze.

The epidermal cells on the pedicels of the tentacles have strongly cutinized outer walls which are impermeable to salt and sugar solutions. The solution reaches the inner cells of the tentacle by way of the gland at the apex and the broken end at the base where the tentacle was formerly attached to the leaf blade. In many cases it was found necessary to puncture the cuticle in several places with a needle, or else to cut the pedicel into segments with a razor, in order to give the solutions access to all the cells of the tentacles.

1. *Straight tentacles.*—Examination of over thirty normal marginal tentacles with potassium nitrate and of twenty with glucose solutions showed the cells of the apical half of the pedicel to have a higher osmotic concentration than the cells of the basal half. The latter ranged from eight to nine atmospheres; the former from nine to eleven. In a few instances the cells on the dorsal and ventral surfaces of the basal portion of the pedicel had a higher osmotic concentration than the cells on the flanks. De Vries ('86, pp. 4, 5) found that the cells of *Drosera* tentacles were plasmolyzed by a three per cent. solution of potassium nitrate, but not by a two per cent. solution. This is seen to hold for all the stalk cells excepting those at the apical end just below the gland.

2. *Bending tentacles.*—The glands of numerous tentacles were stimulated by rubbing with a fine brush and after fifteen to twenty minutes, when the tentacles had bent through an angle of 90° to 120°, they were removed and placed in a two per cent. potassium nitrate solution. This treatment did not cause the tentacles to unbend. They were then mounted in some of the same solution and covered with a supported cover-glass. Since the tentacles were curved, the different effect of the solution on the convex and concave sides of the tentacle could be observed. In nearly all cases where the movement was rapid, the two per cent. potassium nitrate solution had plasmolyzed the cells in the bent region on the convex or abaxial side, while the cells on the concave or adaxial side showed no effect. Similar results were obtained by using a 5.4 per cent. glucose solution. Examination of fifty tentacles with potassium nitrate and of thirty-five with glucose showed the osmotic concentration in the abaxial cells to be from six to eight atmospheres, in the adaxial cells from eight to nine atmospheres. The osmotic concentration of the cells on the convex side had therefore diminished during bending; that of the cells on the concave side

had remained practically unchanged. The greatest diminution in the osmotic concentration of the cells on the convex side was observed in those tentacles that reacted most rapidly. In a few cases of exceptionally slow movement no diminution was observed, the osmotic concentration being either eight or nine atmospheres. The osmotic concentration of the cells in the upper half of the stalk was found to be the same as in the unbent tentacle.

3. *Bent tentacles.*—Tentacles were stimulated by placing small flies on their glands, and after bending had proceeded as far as possible the tentacles were removed and examined. In twenty-five tentacles treated with potassium nitrate solutions and fifteen tentacles treated with glucose solutions, the cells at the base of the pedicel and in the bent region had an osmotic concentration of nine to eleven atmospheres, there being no difference between the two sides of the tentacle. The cells of the apical portion of the pedicel were found to have an osmotic concentration of ten to thirteen atmospheres. In a few exceptional cases the cells in the latter region appeared to have a higher osmotic concentration, but the detection of plasmolysis was particularly difficult because these cells were smaller than the basal cells and their contents were strongly aggregated.

4. *Unbending tentacles.*—Twenty tentacles in process of unbending were examined with potassium nitrate solutions and the results were checked by the examination of twelve more with glucose solutions. The osmotic concentration of the cells in the basal half of the pedicel was from eight to ten atmospheres; in the apical half from nine to eleven. No difference was observed in the osmotic concentrations of the cells on the concave and convex sides.

5. *Unbent tentacles.*—Eighteen tentacles which had become straight after completing a reaction were examined and found to be similar in osmotic concentration to the normal tentacles before reaction.

The experimental data given above are summarized in the following table:

Three significant facts should be noted, namely:

1. The osmotic concentration of the pedicel cells increases from the base to the apex.

Tentacles	Straight	Bending	Bent	Unbending	Unbent
Basal half of pedicel:					
Abaxial side	8 9	6 8	9 11	8 10	8 9
Adaxial side	8 9	8 9	9 11	8 10	8 9
Apical half	9 11	9 11	10 13	9 11	9 11

2. During rapid bending the osmotic concentration of the abaxial cells in the growing region decreases.

3. When the tentacles are bent, the cells have a higher osmotic concentration than at any other time.

2. RABDOIDS

Rabdoids were first discovered by Gardiner ('85) in *Drosera dichotoma*, and he states that in *Dionaea*, *Drosera rotundifolia* and other species of *Drosera* rabdoids occur which resemble those of *Drosera dichotoma*. Gardiner described the rabdoid as a body, usually spindle-shaped or acicular, which occupies such a position that it stretches diagonally across the cell from end to end, the two extremities being imbedded in the cell protoplasm. They were present in all the epidermal cells of *Drosera dichotoma* leaves except the gland cells and the cells immediately beneath the glands. In the bending region of those tentacles capable of movement they were larger in the epidermal cells on the abaxial side than on the adaxial side where they were very small or apparently absent. When these cells lost their turgidity the rabdoids contracted and separated into two or more parts, but regained their spindle shape when turgidity was restored. A sudden blow on the cover glass also caused the rabdoids to assume a spherical form.

The presence of rabdoids in the epidermal cells of *Drosera rotundifolia* leaves was confirmed. They occur in all the epidermal cells of the petiole, of the leaf blade and of the basal portion of the tentacles, including the bending region. Each cell contains a single rabdoid, rarely two rabdoids, situated near the outer wall and parallel with it. After a leaf has fed on insects, the rabdoids are distinctly larger than before. When plants are deprived of insectivorous food for any considerable period, the rabdoids dwindle until they are barely noticeable. Sudden shocks produced by tapping the cover glass or gradual pressure sustained for a considerable period of time cause the rabdoids to alter their shape.

They contract at each end so that they have the appearance of dumb-bells, and finally separate into several disk-shaped parts. In extreme cases they separate into a large number of droplets which exhibit Brownian movement. No marked difference was observed in the size of the rabdoids on opposite sides of the tentacle in the bending region, and no alteration was visible during movement. The function of the rabdoids is not apparent. It seems probable, however, that they are connected in some way with the process of secretion, rather than with the mechanics of movement. Gardiner ('85) suggested that they might be reserve material or some substance used up during secretion. This seems to be borne out by the fact that they are of protein composition according to Tunmann ('13, p. 481).

3. UNBENDING BY PLASMOLYSIS

Although a two per cent. solution of potassium nitrate usually plasmolyzes the cells on the convex side of a bending tentacle, this does not cause the tentacle to become straight (see De Vries, '86, p. 5). More concentrated solutions produce unbending. For a short time after the tentacle is fully bent complete plasmolysis still causes unbending, but when the tentacle has been bent a considerable period and during unbending, plasmolysis does not alter its shape.

The xylene experiment which W. H. Brown ('12, '16) made on *Dionaea* and *Mimosa* was tried on *Drosera* tentacles, but no positive results were obtained. Bent and bending tentacles were killed in boiling water, treated with 95 per cent. alcohol, absolute alcohol and xylene. No unbending ensued. This may indicate a difference between the mechanics of movement in *Drosera* and in such plants as *Dionaea* and *Mimosa*. However, the failure of the experiment may have been owing to faulty technique, although the description of the process by Brown ('16, p. 78) was followed in detail.

III. DISCUSSION

1. INCREASED TURGIDITY AS THE MEANS OF MOVEMENT

The straightening of bent tentacles by plasmolysis shows the cell elongation, which is the immediate cause of bending, to be a passive stretching of the walls by turgidity. This conclusion is corroborated by direct observation. During bending the cells on the convex side in the curved region as seen under the microscope are noticeably distended, the outer walls appearing in optical cross-section as arcs extending between the end walls. A simple way of demonstrating this is afforded by mounting a straight tentacle in a one per cent. solution of tartaric acid, covering it with a supported cover glass and examining under the microscope. Tartaric acid as well as dilute solutions of many other organic and mineral acids induce rapid and violent bending. The acid enters the tentacle through the broken end of the pedicel at the base, where it was formerly attached to the leaf-blade, and affects the bending region directly, for inflexion proceeds even when the gland has not been stimulated in any way either by being touched or by coming in contact with the acid solution.[*] Gardiner ('85) observed that in well-inflected tentacles of *Drosera dichotoma* the cells on the convex side at the bending point are very turgid. It must be borne in mind that turgidity is the external manifestation of a balance between two antagonistic factors; one factor due to the presence of osmotically active substances in solution tends to increase the volume of the cell and to stretch the wall; the other factor due to the elasticity of the cell-wall tends to compress the cell contents. An increase in the size of the cell under such circumstances follows either from an increase in the amount of osmotically active material or from a diminished elasticity of the cell-wall, unless simultaneous changes in permeability interfere.

(a) *Osmotic concentration*

The experimental data show that during bending the osmotic concentration in the cells on the abaxial side of the pedicel in the growing region falls from eight or nine to six or eight atmospheres. It is at once evident that the elongation of the cells is not the result of an increase in the amount of osmotically active material. Exact data concerning the increase in length of the abaxial side

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[*] The bending produced in detached tentacles by this means is frequently astonishing. The tentacle may bend around completely on itself until it forms a spiral. It is known that stimulation of the glands of *Drosera* tentacles is followed by the secretion of an acid. Is it possible that the impulse which is conducted from the gland down the pedicel to the base of the tentacle and which there starts movement is the acid secreted by the gland diffusing from cell to cell?

during bending is given in a previous paper (Hooker, '16). An average of eleven measurements taken in the region of most active growth shows the increase to be about 27 per cent. of the original length. In one typical example (*ibid. f. 6*), cells on the abaxial side (*ibid.* Table III, segment 5) in the bending region grew from 0.45 mm. to 0.57 mm., an increase of 26.6 per cent. Assuming the other dimensions of the cell to remain unaltered, the increase in volume of the cells in this region would be proportional to the increase in length. An increase in volume must be accompanied by a corresponding decrease in osmotic concentration. Thus if the original concentration were eight atmospheres, we should expect as the result of an increase in volume of 26 per cent. an equivalent decrease in osmotic concentration, that is a fall from eight to six atmospheres. When it is considered that the measurements of osmotic concentration were taken before bending was completed, and that soon after the tentacle is bent the cells restore their original osmotic concentration, a process that must commence soon after bending begins, we see that the maximum decrease in osmotic concentration observed is amply accounted for by the increase in volume of the growing cells. The maximum decrease observed was approximately 25 per cent.; the increase in length averaged 27 per cent.; the correspondence is well within the limits of probable error. The alteration of osmotic concentration is therefore a result of the growth of the cells, and not a determining factor of their elongation.

No marked change in the osmotic concentration of the cells on the adaxial side of the bending tentacle was observed at any time. The slight elongation or compression which these cells experience during bending is probably insufficient to make a change of osmotic concentration perceptible. The irregularity in the nature of the alterations on the concave side of the tentacle indicates that this side takes no active part in the bending, but is either stretched or compressed according to the mechanical conditions that happen to prevail in the base of the pedicel. Gardiner ('85) states that the cells on the concave side of well-inflected *Drosera dichotoma* tentacles lose their turgidity at the bending point. No distinct evidence of loss of turgidity by the cells on the concave side of inflected *Drosera rotundifolia* tentacles was observed, however.

The external walls appear in optical cross-section as straight lines extending between the end walls.

(*b*) *Permeability*

It is of course possible that the elongation of the cells on the convex side of inflected tentacles might be caused by increased osmotic pressure, if the detection of the increased osmotic concentration were rendered impossible by a simultaneous increase in the permeability of the cells to the plasmolyzing solutions. The possibility that such is the case here is ruled out by two considerations. Firstly, the determinations of osmotic concentration made with an electrolyte, potassium nitrate, were confirmed by determinations made with a non-electrolyte, glucose. It is highly improbable that there should occur a differential change in permeability of such a nature as to permit increased diffusion of both potassium nitrate and glucose, which at the same time would not permit increased diffusion of the osmotically active material within the cell. Secondly, the correspondence between the increased volume of the elongating cells and the decreased osmotic concentration indicated by experiments cannot be disregarded, since it offers a direct and simple interpretation of the experimental data.

(*c*) *Cell-wall elasticity*

Since there is no evidence that the permeability is altered, and since the osmotic concentration decreases during bending, the increased turgidity of the elongating cells must be due to a decrease in the elasticity of their cell-walls. It is evident that irreversible changes take place in the cell-wall, for the increased size of the cell-wall is soon rendered permanent, probably by the deposition of new cell-wall material. This is shown by the fact that after bending is completed, the cells on the convex side lose their excess turgidity. The distended outer walls become flat, yet the tentacle remains bent. At this stage plasmolysis no longer causes unbending. Gardiner ('85) states that in *Drosera dichotoma* the cells on the concave side not only lose their turgidity after bending is finished, but become flaccid. These irreversible changes in the cell-wall apparently begin soon after bending starts, for when a bending tentacle is forcibly straightened, the distended outer cell-walls do not always return to their original condition, but are frequently crumpled or wrinkled. The rate of change in the cell-wall properties undoubtedly increases during the inflexion. In the same way the decrease in osmotic concentration which results from the increase in volume of the elongating cells is soon compensated for by the formation of new osmotically active material, as is shown by the equality of osmotic concentration on opposite sides of the tentacle a short time after it has become fully bent. This process too is probably initiated soon after inflexion begins, with the result that no marked difference in osmotic concentration is noticeable on opposite sides of tentacles which bend slowly. In the last analysis, therefore, the growth which causes the inflexion of *Drosera* tentacles is the activity of the protoplasm in manufacturing cell-wall substance and osmotically active material.

2. COMPARISON WITH GEOTROPIC MOVEMENTS

The movement of *Drosera* tentacles is seen to be brought about by the same mechanism found in geotropically reacting organs, where Kraus ('82, p. 87) and Noll ('88, p. 511) observed a decrease in the osmotic concentration of the cells on the convex side of roots and stems, which was particularly evident in case of rapid bending. The subject is well summed up by Jost ('13, p. 580) in the following paragraph, and his remarks apply to the bending of *Drosera* tentacles with equal felicity:

> In all cases that have been more carefully studied, the immediate cause of the bending is a difference of growth in length on opposite sides. The surface growth of the membranes here as elsewhere is preceded by stretching due to turgidity, and this is gradually made permanent by growth. If an organ be plasmolyzed at the beginning of the geotropic bending it again becomes straight, but later the curvature is permanent. The stretching is unequal in amount on the two opposite sides. This difference might consist in an increased osmotic pressure on the convex side and diminished osmotic pressure on the concave side, but this is by no means the case; the pressure on the concave side seems rather to remain unchanged, while that on the convex side diminishes during bending. This result is not so astonishing when we consider that the rate of growth does not depend directly on the amount of osmotic pressure, but that this latter frequently depends on the increase in cell-volume. The unequal stretching of the opposite sides due to turgidity must therefore be connected with an alteration in the elasticity of the cell-walls, the convex side becoming more extensible. Of course in unicellular organs (in sporangiophores of the Mucorineae, for example), the bending must depend solely on a change in the elasticity of the cell-wall.

3. ALTERATION OF CELL-WALL ELASTICITY

In the opinion of Noll ('95, p. 65) the change in the plasticity of the cell-wall is analogous to the gradual change that takes place in a strung bow, which after having been left strung a long time does not return completely to its original shape when unstrung. This plastic change does not involve any permanent diminution of elasticity, however, for the bow returns to its new shape after bending. The source of energy for this change in plasticity is found in the stored energy of elastic tension. The change from a condition of elastic tension to a plastic alteration of shape is compared by Noll ('95, pp. 79-81) to changes produced in rubber by vulcanization, during which process any elastic deformations that happen to be present are transformed in a greater or less degree to permanent alterations of shape. In bending plant organs he assumes that the protoplasm secretes one or more substances which act on the cell-wall as vulcanizing sulphur acts on crude rubber.

The correlation between the molecular structure and the physical properties of metals, which has been discovered in recent years by metallographists, offers a more satisfactory interpretation of the changes in the physical properties of the cell-wall. The alteration of the strength, ductility and elasticity of metals produced by mechanical treatment and by heat are based on changes in molecular structure, which consist in the rearrangement of the relative amounts of the phases that enter into the composition of the metal. Two phases are usually present, a crystalline phase and an amorphous phase that cements the crystals together. The strength and ductility of a metal are found to be increased and the elasticity diminished by an increase in the amount of the amorphous phase and a decrease in the amount of the crystalline phase. Conversely the elasticity would be increased and the strength and ductility diminished by an augmentation of the crystalline phase and a decrease in the amorphous phase. It is probable that changes in the elasticity of plant cell-walls are also produced by alterations in the molecular structure. The cell-wall is undoubtedly a mixture of phases in heterogeneous equilibrium. It seems plausible that changes in elasticity are effected by a readjustment between these phases. Possibly an amorphous and a crystalline phase are present, in which case an increase in the proportion of the former to the latter would decrease the elasticity and the reverse change would restore the original properties. Whatever changes in molecular structure actually occur, they must be controlled and regulated by the activity of the protoplasm.

4. AUTOTROPIC NATURE OF UNBENDING

(a) *Comparison of autotropic with hydrotropic stimulus*

When roots are exposed to a hydrotropic stimulus, greater evaporation takes place from the cells of the drier side and this tends to increase their osmotic concentration. The resulting inequality of osmotic concentration or changes which this induces on opposite sides of the root constitute the stimulus that released the hydrotropic reaction, which consists in bending toward the source of moisture by faster growth on the side with the higher osmotic concentration (Hooker, '15). It is characteristic of hydrotropic reactions that small differences in the relative moisture on opposite side of the exposed root, and consequently small differences in osmotic concentration are sufficient to produce changes that release a reaction. On the other hand the exposure must be prolonged, for the reaction does not commence until the roots have been subjected to a hydrotropic stimulus for at least six hours. Bending proceeds much more slowly than in geotropic reactions.

The autotropic unbending of *Drosera* tentacles as well as of geotropically bent roots and shoots resembles hydrotropic reactions in several respects. The unbending is produced by growth on that side of the organ that tends to have the higher osmotic concentration during bending. The reaction does not begin until some time after the bending, and it proceeds at a very much slower rate. During this process no difference of osmotic concentration was ever observed in opposite sides of the tentacle, which indicates that the formation of osmotically active material keeps pace with the increase in volume of the growing cells.

(b) *Internal changes that follow bending*

In a discussion of the autotropic unbending of tendrils, Fitting ('03, p. 612) expresses the opinion that the unbending may be a response to a new stimulus produced by "the inequality of conditions, of pressure-distribution, tissue-tension, etc., which are established in the cells on opposite sides of the originally straight organ as a result of an attempted or executed reaction."

The inequality of conditions that should constitute the autotropic stimulus may be found in the changes produced by the difference of osmotic concentration observed in bending roots and tentacles, since just such a difference induces an analogous reaction in hydrotropically stimulated roots. It has been emphasized elsewhere (Hooker, '16, p. 21) that the increase in the rate of growth which produces the unbending of *Drosera* tentacles proceeds in the same manner as that which causes bending, in both cases commencing near the base and extending apically. Moreover, the amount of growth that occurs during unbending is nearly the same in amount and is distributed in much the same manner as during bending, so that the unbent tentacle is straight and reaches approximately the same position it held before the reaction. This nice regulation is intelligible when we consider that the changes resulting from the decrease in osmotic concentration during bending are directly proportional to the increase in volume of the growing cells. It is not to be denied that other factors may coöperate in producing the autotropic reaction, but the striking similarity with hydrotropic reactions indicates that the effects of the difference in osmotic concentration during bending are most significant.

When an insect is caught and digested, the unbending of the tentacle is postponed a considerable time, occasionally several days. It would appear that the absorption of food material through the gland inhibits the reaction to the inequality of conditions produced by the bending. All the cells of the tentacle from base to apex are generally aggregated while food is being absorbed. According to Gardiner ('85) the state of aggregation is accompanied by a loss of water and he found that the injection of water into the tissue stopped aggregation at once and restored the cells to their normal condition. This probably accounts for the fact that the osmotic concentration in the cells of bent tentacles is higher than under any other circumstances. When absorption ceases, aggregation stops and the tentacles unbend in the normal manner. This is brought about by increased turgidity of the cells on the concave side. Without doubt the same factors found to determine bending are involved in the unbending, but the process is so slow that it resembles ordinary plant growth. It does not seem probable that this deferred reaction can be a direct response to changes produced by a difference of osmotic concentration which existed during bending, but is now completely effaced. In these cases unbending is probably a response to changes taking place as the result of a cessation of absorption and the end of the aggregated condition. Nevertheless the effects of the difference in osmotic concentration are conditioning factors of the unbending reaction, for an accelerated rate of growth on the adaxial side of the tentacle occurs only after previous bending.

IV. SUMMARY

The osmotic concentration in cells of *Drosera rotundifolia* tentacles was measured by plasmolysis in potassium nitrate and glucose solutions. Measurements were made on straight, bending, bent and unbending tentacles. The osmotic concentration in the cells on the abaxial side of the stalk, in the growing region, was found to diminish during bending; no change was observed on the adaxial side. The decrease in osmotic concentration is accounted for by the increase in volume of the cells, and is therefore considered an effect and not a cause of their elongation. There is no indication that changes in permeability occur.

The elongation is produced by a decrease in the elasticity of the cell-walls, and is later fixed by growth. The movement of tentacles is therefore brought about by the same mechanism found in geotropically reacting organs, where a decrease has been observed in the osmotic concentration in the cells whose growth causes bending.

Similarities between hydrotropic reactions and autotropic unbending of tentacles and of geotropically bent roots indicate that the growth on the concave side which brings about the unbending is a response to changes resulting from the difference in osmotic concentration present during bending. As in hydrotropic reactions, growth takes place on the side with the higher osmotic concentration.

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Studies in the genus Lupinus—I. A new species of the subgenus Platycarpos

Charles Piper Smith

I have recently made a critical study of the material usually determined as either *Lupinus microcarpus* Sims or *L. densiflorus* Benth., and have prepared an illustrated paper, monographic in scope, giving in detail my conclusions and a new classification. As conditions beyond my control prevent the prompt publication of this work, I deem it expedient to publish at once a preliminary paper.

Heller (Muhl. 8: 87. 1912) has already proposed a separation of the subgenus *Platycarpos* into two sections, applying the group-name "PUSILLI" to the loosely flowered small species of the Mexican Plateau, the Great Basin, and the Rocky Mountain region. The verticillate and commonly larger plants of the Pacific Slope should accordingly be assembled into a group that would properly bear the name "MICROCARPI."

The published names of members of this group indicate twelve species and one variety. Of these *L. microcarpus* Sims, *L. densiflorus* Benth., *L. luteolus* Kell., and *L. malacophyllus* Greene are recognized as species by authors generally and are accepted by me *L. horizontalis* Heller I am also able to accept as a species; but the other names, except for two which are acknowledged as synonyms, I must use as representing varieties of either *L. microcarpus* or *L. densiflorus*.

Most of the North American plants commonly determined as *L. microcarpus*, however, I am not able to accept as Sims' species, and in order to draw a more satisfactory line of distinction between the initial species of Sims and Bentham, and, at the same time do justice to a group of unnamed variations that I deem worthy of recognition, I propose the following species as new:

Lupinus subvexus sp. nov.

Eramosus vel ramosus, 20–40 cm. altus, caule cum eramoso plerumque elongato foliis sparsis, villoso pilis 2–4 mm. longis:

foliolis 6–10, 20–30 cm. longis, oblanceolatis, apice obtusis vel rotundatis, subter laxe villosis; pedunculis elongatis, verticillis 3–7, distantibus; floribus ad anthesin postea pandentibus ascendentibus vel suberectis, 14–16 mm. longis; pedicellis prope 1 mm. longis, robustis; bracteis villosis, vix 10 mm. longis: calyce ebracteolato, prope 10 mm. longo, subter villoso pilis prope 1.5 mm. longis, labio superiore diverso prope 2 mm. longo, inferiore inflato 3.5–4 mm. lato, 2-dentato, sinu dentis vestigio instructo vel sine eodem, dentibus vix 1 mm. longis; corolla atro-purpurea praesertim vexilli alarumque dimidiis terminatis; vexillo apice rotundato 13–15 mm. longo, 8 mm. lato, abrupte contracto ungue 4–5 mm. lato; alis 11–13 mm. longis, ad basin super frequenter non ciliatis; carina 10–11 mm. longa suberecta vel aliquantum curvata; leguminibus prope 12 mm. longis: semina non vidi.

Simple or branched, loosely villous, the hairs 2–4 mm. long; whorls three to seven, well-separated; flowers spreading in anthesis, evidently ascending to suberect later; calyx ebracteolate, quite villous below; pods not secund. The typical plant has the lower lip of the calyx evidently inflated (subsaccate) near the base, large flowers with much of the banner and wings dark purple, and the banner rounded apically. Most of the varieties have the lower calyx-lip scarcely or not at all inflated and smaller flowers with the banner gradually narrowed to an acute apex.

The type is *Heller & Brown 5415*, collected near Madison, Yolo county, California, April 29, 1902, sheet 9586 in the Dudley Herbarium of Stanford University.

Descriptions of the varieties recognized, distribution, full citations of specimens determined, keys, and figures of floral parts will be given in the main paper when finally published.

COLLEGE PARK, MARYLAND

INDEX TO AMERICAN BOTANICAL LITERATURE

1915-1917

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the word America being used in the broadest sense.

Reviews, and papers that relate exclusively to forestry, agriculture, horticulture, manufactured products of vegetable origin, or laboratory methods are not included, and no attempt is made to index the literature of bacteriology. An occasional exception is made in favor of some paper appearing in an American periodical which is devoted wholly to botany. Reprints are not mentioned unless they differ from the original in some important particular. If users of the Index will call the attention of the editor to errors or omissions, their kindness will be appreciated.

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BULLETIN

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The Chenopodiaceae of the North American Flora

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The North American Chenopodiaceae have been treated previously in two monographic accounts. The first of these was that of Moquin-Tandon in De Candolle's Prodromus,[†] published in 1849. Moquin had access to a very limited number of specimens, for at that time scarcely any collections had been made in the western United States and northern Mexico, the parts of the continent in which the family is most extensively represented. The other monograph of the North American species, by Watson, appeared in 1874.[‡] The latter author had the advantage of fairly ample collections, and his monograph is very useful even now, although many additional species have been described in recent years. Watson enumerated 83 species; the present writer, in the treatment of the family for the North American Flora,[§] has recognized 223. The great increase in number of species in the last forty years is due partly, of course, to a different conception of specific limits, but chiefly to more extensive exploration. Several European and South American species have become naturalized only in comparatively recent years. It is not probable that the present number will be greatly increased unless from parts of Mexico still unexplored.

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[†] 13^2. 41–219. 1849.

[‡] Proc. Amer. Acad. 9: 82–126. 1874.

[§] 21: 3–93. 27 N 1916.

[The BULLETIN for August (44: 369–410) was issued August 10, 1917.]

This family is not an easy one for study, especially because of the great individual variation frequently found within a species. It is often extremely difficult to decide where specific lines should be drawn, consequently it will be many years before all American botanists agree upon a classification. Such a condition is not peculiar to the Chenopodiaceae, but it does seem more characacteristic of this family than of some of the closely related ones, such, for instance, as the Amaranthaceae, in which the species are clearly defined.

The present notes are intended to explain some of the more important changes in nomenclature which the writer has found necessary, as well as to illustrate by citation of specimens the material upon which some of the new species are based. In the case of new species founded upon a single collection, no comments seem necessary, the basis of segregation being explained sufficiently by the keys. In the course of the preparation of the account of the family, the writer examined, besides the material in the United States National Herbarium, all that in the Gray Herbarium and the herbaria of the New York Botanical Garden and the Missouri Botanical Garden. Certain material was lent, also, from the herbaria of the Field Museum of Natural History, the University of California, and Professor W. L. Jepson.

CHENOPODIUM L.

In none of the genera of the Chenopodiaceae are the species quite so perplexing as in *Chenopodium*, particularly in the group of *C. album* L. and its allies. This applies not only to the species of eastern North America, which are mostly adventive from Europe, but also to the western ones, which are endemic. The chief character relied upon for specific segregation has generally been leaf form, which, in any group of flowering plants, is seldom by itself a satisfactory criterion of species. In the present instance it is doubtless the best character available, at least in the case of the European species.

In Europe much attention has been devoted in recent years to a study of *Chenopodium*, a study based not only upon large series of herbarium specimens, but also upon cultivated pedigreed plants.

As a result an almost endless number of forms have been described and named. Many of these minor forms occur in North America, and any one who is interested in their segregation could find here an almost unlimited field for investigation. To the writer, however, most of the forms recognized abroad seem to be based upon such slight and inconstant characters that they scarcely deserve serious consideration, especially in America, where the flora as a whole is still so imperfectly known.

In Europe, too, many presumed hybrids have been described, not only hybrids between species but even between hybrids. Most of these are known only from cultivated plants. If hybridization is a common phenomenon in the genus it may well explain, partially at least, the obstacles to the determination of specific limits. It is unfortunately true that the North American species are still but poorly understood, and that a wholly satisfactory arrangement of them is apparently not to be secured at present.

CHENOPODIUM PALLESCENS Standley, N. Amer. Fl. **21**: 15. 1916

The plants referred to this species have passed as *C. leptophyllum* Nutt. and *C. subglabrum* (S. Wats.) A. Nels. They are most like the latter species in pubescence and habit, but are distinguished from both by having the pericarp firmly attached to the seed. The following specimens have been seen:

MISSOURI: Allenton, on stony hills, August 30, 1887, *Eggert;* near Pacific, *Eggert;* Webb City, *E. J. Palmer 1041;* Sheffield, *Bush 553*. OKLAHOMA: Lincoln County, 1895, *Blankinship;* Sapulpa, *Bush 489*. TEXAS: Dallas County, *Reverchon 818*. NEW MEXICO: Roswell, *Earle 326* (type).

CHENOPODIUM INAMOENUM Standley, N. Amer. Fl. **21**: 15. 1916

Although closely related to *C. leptophyllum*, which it resembles in general appearance, this species has the pericarp adherent to the seed, instead of free. It has a wide range, as shown by the following list of specimens examined.

OREGON: P Ranch, *Griffiths & Hunter 281*. MONTANA: Horr, *Mearns 3318*. WYOMING: Bitter Creek, Sweetwater County, *A. Nelson 3704a*. UTAH: Henry Mountains, *Jones 5695bi*. NEVADA: Ely, *A. E. Hitchcock 1237*. ARIZONA: Nagle's Ranch, *Jones 6050f.* NEW MEXICO: Mangas Springs, 1903, *Metcalfe;* Farmington, *Standley 7101.* CHIHUAHUA: near White Water, *Mearns 2286* (type).

CHENOPODIUM HIANS Standley, N. Amer. Fl. **21**: 16. 1916

Of the group of *C. leptophyllum*, but distinguished from all the related species by its ill-scented foliage. This character, which has been ignored heretofore, seems to be a very good one. The European *C. Vulvaria* L. has always been noted for its diagreeable odor, and several American species possess the same character. Their odor is quite different from that of *C. ambrosioides* L. and its allies. The type of *C. hians* was collected near Dulce, New Mexico (*Standley 8129*) and the species has been obtained by the writer at Ensenada (No. 10764) and Ute Park in the same state. A specimen from Bear Creek, near Eagle Peak, Wyoming, collected by Schuchert, is also referable here. The species is distinguished, also, by the erect calyx, which does not embrace the fruit closely as in related species.

CHENOPODIUM CYCLOIDES A. Nels. Bot. Gaz. **34**: 363. 1902

The original collection, from Grant County, Kansas, is too immature to show the true characters of this species and might at first glance be referred to *C. leptophyllum* Nutt. The only other locality known for the plant is on sandhills in Dona Ana County, New Mexico, where it is abundant, according to Mr. E. O. Wooton, who has obtained excellent and ample specimens at two different times. The species is distinguished from all those of the *C. leptophyllum* group by its calyx, almost rotate at maturity and with ecarinate lobes, and by its bright red pericarp. Indeed, the general appearance of the mature plant does not at first remind one of the genus *Chenopodium.*

CHENOPODIUM NEVADENSE Standley, N. Amer. Fl. **21**: 16. 1916

A relative of *C. atrovirens* Rydb., but distinguished by having the seed adherent to the pericarp, and by the small leaves and seeds. The type is from Winnemucca Lake, Nevada (*Kennedy 1903*). Shockley's No. 542 from Candelaria also belongs here, besides one or two other Nevada collections examined.

CHENOPODIUM PRINGLEI Standley, N. Amer. Fl. 21: 18. 1916

Allied to *C. Fremonti* S. Wats., to which the specimens have been referred, but distinguished by the form of the leaf blades, which are coarsely sinuate-dentate and only slightly lobed. In *C. Fremonti* the well-developed lobes are usually entire, at least the large terminal one. The type of *C. Pringlei* was collected near Dublán, Hidalgo, Mexico (*Pringle 9283*). Pringle's No. 6570 from Tule, Hidalgo, is the same species.

CHENOPODIUM NEOMEXICANUM Standley, N. Amer. Fl. 21: 19. 1916

Related to *C. Fremonti* S. Wats., but differing in the adherent pericarp. The type was collected along Mineral Creek, Sierra County, New Mexico, by O. B. Metcalfe (No. 1413), and the species has been collected in the Chiricahua Mountains of Arizona by J. C. Blumer (No. 1409).

CHENOPODIUM ARIZONICUM Standley, N. Amer. Fl. 21: 19. 1916

A segregate from *C. Fremonti*, distinguished primarily by having the pericarp adherent to the seed. It is distinct from *C. neomexicanum* in the size of the seed, scarcely more than half as large as in the latter. The following specimens have been seen:

ARIZONA: Santa Rita Forest Reserve, *Griffiths 5982* (type); Santa Rita Mountains, *Griffiths 6011;* near Tucson, 1911, *Wooton;* Rincon Mountains, *Blumer 3585*.

CHENOPODIUM AMARANTICOLOR Coste & Reynier, Bull. Soc. Bot. France 54: 181. 1907

A species not reported previously from North America. It is a relative of *C. album* L., from which it is distinguished by its broad leaf blades and the red coloration of the upper leaves and inflorescence. Specimens from Thomasville, Georgia (*E. B. Taylor*, 1909) and Santiago de las Vegas, Cuba (*Abarca 2794*), are referred here. The native habitat of the plant is not known, but it has been found as a weed in France. It is sometimes cultivated as a foliage plant.

CHENOPODIUM VIRIDE L. Sp. Pl. 219. 1753

Chenopodium opulifolium Schrad.; Koch & Ziz, Cat. Pl. Palat. 6. 1814.

This is a well-known Old World species which generally has been known as *C. opulifolium*. *C. viride* L., however, was based upon a plate which evidently represents the same plant. The Linnaean name has been applied usually to the plant which is properly known as *C. paganum* Reichenb. So far as the writer knows, *C. viride*, in the sense in which the name is used here, has never been reported from North America, but the rather numerous collections cited below should all be referred to it. It differs from *C. album*, with which American specimens have been confused, in having the blades of the lower leaves as broad as long and, when dry at least, of a peculiar bluish-green color.

ONTARIO: Ottawa, *Macoun 5872;* Sandwich, *Macoun 54723*. RHODE ISLAND: Providence, July 31, 1892, *J. F. Collins*. MARYLAND: Cumberland, September 12, 1898, *Steele*. ILLINOIS: East St. Louis, September, 1894, *Eggert;* Rockford, 1880, *Bebb;* Mt. Carmel, July 12, 1894, *Schneck*. MISSOURI: Joplin, *Bush 2041*. TEXAS: Big Springs, June 11, 1900, *Eggert*.

CHENOPODIUM DACOTICUM Standley, N. Amer. Fl. **21**: 22. 1916

This species is related to *C. album* and *C. ferulatum* Lunell, but appears sufficiently distinct in the very coarse, loose pubescence, ill-scented foliage, and coarsely punctate seeds. The following specimens are in the National Herbarium:

SOUTH DAKOTA: Cedar Pass, *Over 6175* (type); Fall River Falls, *Rydberg* 964; Talus slopes, badlands, Washington County, August 4, 1914, *Over;* summit of Sheep Mountain, Pennington County, August 20, 1914, *Over;* badlands near White River, August 1, 1914, *Over;* White River, *Over 6211*.

The same plant apparently, doubtless adventive, has been collected in waste ground at Courtney and Sheffield, Missouri, by B. F. Bush (Nos. 7058A, 7066).

CHENOPODIUM PETIOLARE H. B. K. Nov. Gen. & Sp. **2**: 191. 1817

North American botanists have overlooked this species, but in Europe it has been generally recognized in recent years, and North

American material has been referred to it by European writers. It has been confused with C. *album*, to which it is very closely related, differing chiefly in the deeply lobed blades of the upper leaves, and the dull rather than lustrous seeds. It is widely distributed in the Southwest. Some of the numerous collections at hand are cited below.

COLORADO: Durango, *Baker, Earle, & Tracy 487*. NEW MEXICO: between Santa Fe and Canyoncito, *Heller 3787;* Chama, *Standley 6515;* Ensenada, *Standley & Bollman 11097;* Mangas Springs, *Metcalfe 216;* Mesilla, *Wooton 85*. ARIZONA: Willow Spring, *Palmer 586;* Flagstaff, July 3, 1891, *MacDougal*. NEVADA: Truckee Valley, *Bailey 969*. CALIFORNIA: Cameron's Ranch, *Schoenfeldt 3682;* Panamint Mountains, *Coville & Funston 813*.

CHENOPODIUM ARISTATUM L. Sp. Pl. 221. 1753

This is known definitely to occur in Siberia, but whether it is found in North America is still doubtful. It has been reported from Alaska and Mexico, and it is reasonable to expect it in Alaska, although none of the numerous collectors who have visited that region in recent years have found it. The occurrence of the species in Mexico seems very doubtful. The plant is so distinct that it scarcely seems probable that any other species would be mistaken for it. There is always the possibility of a misplaced label as an explanation of an otherwise inexplicable extension of range.

CHENOPODIUM INCISUM Poir.; Lamarck, Encyc. Suppl. 1: 392. 1810

?*Chenopodium graveolens* Lag. & Rodr. Anal. Ci. Nat. 5: 70. 1802.
Teloxys cornuta Torr. Pacif. R. R. Rep. 4: 129. 1857.
Chenopodium cornutum Benth. & Hook.; S. Wats. Bot. Calif. 2: 482. 1880.

Chenopodium incisum has a wide range, extending from southern Colorado, through Mexico and Central America, to South America, besides occurring in Africa. Probably it should be known as *C. graveolens* Lag. & Rodr., but the data afforded by the original publication of that species are insufficient for certainty. The plant of the United States has been known generally as *C.*

cornutum, but it differs in no way from the mass of Mexican material. Tropical forms have been referred commonly to *C. foetidum* Schrad., a different plant of which the writer has seen no North American specimens.

CHENOPODIUM DISSECTUM (Moq.) Standley, N. Amer. Fl. **21**: 26. 1916

Ambrina dissecta Moq. Chenop. Enum. 38. 1840.

Apparently this is a very rare plant. Before seeing material of it the writer presumed, from Moquin's description, that it was only a form of *C. incisum*. It is, however, quite distinct, being more closely related to *C. Botrys* L., as was apparent when the two following collections were discovered, both of which agree perfectly with the original description.

MEXICO: Saltillo, 1898, *Palmer 353;* Valley of Mexico, *Schaffner 437*.

CHENOPODIUM VAGANS Standley, N. Amer. Fl. **21**: 26. 1916

Chenopodium chilense Schrad. Ind. Sem. Hort. Gotting. **1832**: 2. 1832; Linnaea **8** (Litt.-Ber.): 25. 1833. Not *C. chilense* Pers. 1805.

Although most of the segregates from *C. ambrosioides* are too poorly marked to deserve specific rank, the one to which the above names have been applied seems to be an exception. It has apparently been overlooked by American botanists, the collections at hand having been identified mostly as *C. anthelminticum* L. *C. vagans* differs from all the forms of *C. ambrosioides* in its white-villous stems and in the conspicuously dentate or sinuate-pinnatifid leaves of the inflorescence. In fruit the plants have a characteristic appearance because of the very numerous, much elongate, slender spikes. The species is a native of Chile, and probably is adventive in California. The following specimens have been examined:

CALIFORNIA: Clinton, *Hansen 2020;* Ione, *Braunton 1185;* Tehama, *Ward 101;* Ukiah, *Chestnut 349;* North Fork, *Griffiths 4648;* Mendocino, *H. E. Brown 949;* Crystal Springs, *Elmer 4134;* without locality, 1860–67, *Rattan*.

A specimen "Ex Herb. E. & C. Faxon" collected at Boston, Massachusetts, in 1878, is probably *C. vagans*, but the plant is too young for definite determination.

CHENOPODIUM AMBROSIOIDES L. Sp. Pl. 219. 1753

This species, a native, presumably, of tropical America, is now widely diffused through the tropics of both hemispheres, and is naturalized in many regions far outside the tropics, especially in North America. As a consequence of its extensive range it exhibits much variation, but none of the forms seem worthy of specific recognition and few of them of rank as subspecies. *C. anthelminticum* L., which has been recognized in most North American manuals as a species or subspecies, does not seem to be worthy nomenclatural recognition. It is apparently nothing more than a poorly marked seasonal variation.

CHENOPODIUM FARINOSUM (S. Wats.) Standley, N. Amer. Fl. **21**: 28. 1916

Chenopodium murale farinosum S. Wats. Proc. Amer. Acad. **9**: 97. 1874.

Although described as a variety of *C. murale* L., this plant is far removed from that species and finds its nearest ally in *C. glaucum* L., differing from the latter in its large size and large glabrate leaves. In North America it seems to be confined to California, but, like some other Californian plants, it occurs also in western South America and in Paraguay. The following collections are representative:

CALIFORNIA: without locality, 1853–56, *C. Wright;* Santa Cruz Mountains, *A. E. Hitchcock 183;* Nigger Slough, Los Angeles County, *Braunton 558;* San Francisco, *Bolander 2489* (type).

CHENOPODIUM SALINUM Standley, N. Amer. Fl. **21**: 29. 1916

The above name is proposed for the native North American plant which has been referred to the Old World *C. glaucum*. The latter is rather sparsely adventive from New Brunswick to Virginia and as far west as Nebraska. *C. salinum* ranges from Manitoba and Alberta to New Mexico and Arizona, and has been collected in Missouri, where, doubtless, it is adventive. The North American plant has stout, dense, short, mostly axillary spikes of flowers, with sparsely villous rachises, and finely tuberculate seeds; the European plant has slender, elongate, interrupted, axillary and terminal spikes with glabrous rachises, and smooth seeds. While the differences may not seem very great, they are easily recognized when the two forms are compared. There seem to be no intermediate plants.

BLITUM L.

BLITUM VIRGATUM L. Sp. Pl. 4. 1753

An Old World species, closely related to *B. capitatum* L., but distinguished by the leafy rather than naked inflorescence, obtuse margin of the seeds, and copiously branched stems. It has escaped recognition by American botanists, but specimens in various herbaria were collected long ago in Massachusetts and New York, probably mere waifs. It seems to have become naturalized in the Northwest, having been found in Washington (Pullman, 1900, *Piper*), Oregon (Wallowa Mountains, 1897, *Sheldon 8846*), and Idaho (Ketchum, 1911, *Nelson & Macbride*).

ATRIPLEX L.

ATRIPLEX HASTATA L. Sp. Pl. 1053. 1753

Chenopodium subspicatum Nutt. Gen. 1: 199. 1818.
Atriplex lapathifolia Rydb. Mem. N. Y. Bot. Gard. 1: 133. 1900.
Atriplex carnosa A. Nels. Bot. Gaz. 34: 361. 1902.

Recent writers upon the botany of the western United States have insisted that the plants of the Rocky Mountain and adjacent regions previously referred to *A. hastata* were distinct from the beach or salt marsh plant of the Atlantic and Pacific coasts. Their conclusions must have resulted from the paucity of eastern material for comparison. In the large series of northeastern specimens in the herbarium of the New England Botanical Club all the Rocky Mountain forms can be matched without difficulty; and it is easy to find European specimens, also, which agree in essential characters. In Europe names have been given to all the easily recognizable variations, and it would be possible to find American plants referable to many of the European forms. These, however, are based upon too inconsequential characters to deserve attention.

Probably it will never be possible for all botanists to agree upon a treatment of the species of *Atriplex* of the *A. hastata* alliance, and in the past both European and American authors have held widely divergent views as to specific limits within the group. The present writer has recognized eight species in North America, namely: *A. drymarioides* Standley, known from a single Alaskan collection; *A. rosteraefolia* (Hook.) S. Wats., of Washington; *A. alaskensis* S. Wats.; *A. Gmelini* C. A. Mey., ranging from northern California to Alaska; *A. joaquiniana* A. Nels., occurring from British Columbia to central California; *A. littoralis* L., *A. patula* L., and *A. hastata* L. All of these, except the first three, are closely related and are distinguished by comparatively slight variations. *A. Gmelini* and *A. joaquiniana* are probably sufficiently distinct. Of the last three, *A. littoralis* is doubtless the "strongest" species and when properly limited is easily recognized by its linear leaf blades and erect habit. The only American specimens seen that are referable to it are from the coast of Maine, except a few found as waifs in the vicinity of Philadelphia. Both *A. patula* and *A. hastata* seem to the writer to deserve specific rank. While no sharp line can be found to separate the multitudinous forms which are referable to them, the typical form of each represents a well-marked center of variation, which seems to merit more than subordinate rank.

ATRIPLEX ROSEA L. Sp. Pl. ed. 2. 1493. 1763

Atriplex spatiosa A. Nels. Bot. Gaz. 34: 360. 1902.

Although this Old World species has been found along the Atlantic Coast from New York to Florida, it is probably nowhere in this area more than a waif. In the west, however, its status is very different, for although it seems to have been introduced only recently, it has spread with amazing rapidity, its present known range extending from Washington to South Dakota, southern California, and northern Chihuahua. In many parts of its western range it is extremely abundant, so much so that in places it has been cut for hay. In parts of New Mexico it has every appearance of being a native plant, occurring in abundance many miles from a railroad. Its case is somewhat comparable to that of the Russian thistle, a European plant which for some unknown reason has found conditions in America particularly favorable for its spread. In the present instance, however, there seems to be no great harm involved, and the plant may even be beneficial if it is useful as forage. Probably within a few years it will have spread throughout the Great Plains region and the territory westward to the Pacific Coast.

The oldest western specimens in the National Herbarium were collected in Wyoming in 1897. The first Oregon specimens were obtained in 1901, and all those from other western states still later.

ATRIPLEX SACCARIA S. Wats. Proc. Amer. Acad. 9: 112. 1874

Atriplex cornuta Jones, Proc. Calif. Acad. II. 5: 718. 1895.

Among North American species this is remarkable in having strongly dimorphous fruiting bracts. In certain other species also the bracts vary greatly upon a given plant, but in none, except the abnormal *A. hortensis* L. and its allies, do these parts exhibit such striking variation as in *A. saccaria*. The name *saccaria* has been ignored by recent writers upon western plants. It was based upon specimens showing only the small fruiting bracts (the large ones had fallen off, doubtless); hence it is not remarkable that the species has been wrongly identified from the description, and that Mr. Jones once regarded it as a variety of *A. truncata* (Torr.) A. Gray.

ATRIPLEX SORDIDA Standley, N. Amer. Fl. **21**: 47. 1916

Of the *A. argentea* group, differing from that species in the sessile, wholly alternate leaves, and from *A. expansa* S. Wats. in the terete branches, coarse and loose pubescence, and smaller seed. The type was collected in the San Jacinto Valley, California, in 1880, by G. R. Vasey (No. 549). A collection from Santa Monica, California (*Parish 1124*), also belongs here.

ATRIPLEX MOHAVENSIS (Jones) Standley, N. Amer. Fl. **21**: 47. 1916

Atriplex expansa mohavensis Jones, Contr. West. Bot. **11**: 20. 1903.

This name applies to the common plant of central and southern California which has passed as *A. expansa* S. Wats. The latter, however, is restricted to the Rio Grande Valley of southern New Mexico, western Texas, and northeastern Chihuahua. The bracts of the Californian plant are sufficiently distinct to entitle it to specific rank, and the ranges of the two species are widely separated.

ATRIPLEX HILLMANI (Jones) Standley, N. Amer. Fl. 21: 48. 1916

Atriplex argentea Hillmani Jones, Contr. West. Bot. 11: 21. 1903.

This plant seems to have a limited distribution, being confined to Nevada and southeastern Oregon, so far as specimens show. It differs conspicuously from *A. argentea* in the form of the bracts and leaf blades. Representative collections are the following:

OREGON: Malheur, &c., *Cusick 1263*. NEVADA: Leonard Creek Ranch, *Griffiths & Morris 346;* Battle Mountain, *Kennedy 4001*, *A. E. Hitchcock 586;* Lemmon Valley, *Kennedy 2081*.

ATRIPLEX MINUSCULA Standley, N. Amer. Fl. 21: 51. 1916

Most closely related to *A. pusilla* (Torr.) S. Wats., a species of eastern Oregon and northwestern Nevada, from which it is distinguished by its larger bracts, these subhastate and denticulate or crenulate, not ovate and entire. The following collections have been observed:

CALIFORNIA: between Tulare and Tulare Lake, 1892, *Palmer 2728* (type); Laton, *Kearney 33, 34;* near Poso, *Coville & Funston 1249;* without locality, 1872, *Torrey*.

ATRIPLEX PENTANDRA (Jacq.) Standley, N. Amer. Fl. 21: 54. 1916

Axyris pentandra Jacq. Sel. Stirp. Amer. 244. 1763.

Atriplex cristata Humb. & Bonpl.; Willd. Sp. Pl. 4: 959. 1806.

In view of the fact that this plant was first described as a species of the Old World genus *Axyris*, it is perhaps not remarkable that its earliest name has been so long overlooked. More probably it has been neglected because its identity can be confirmed only by a consultation of Jacquin's illustration, which occurs in one of the rarest of botanical works.* This shows that the name *Axyris pentandra* applies to the common plant of southern Florida and the West Indies, heretofore known as *Atriplex cristata*.

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* Sel. Stirp. Amer. Pict. *pl. 235.* 1763.

ATRIPLEX GLOMERATA S. Wats.; Standley, N. Amer. Fl. **21**: 54. 1916

Founded upon Palmer's No. 1156, collected at Parrás, Coahuila, in 1880. The type specimen, in the United States National Herbarium, bears the previously unpublished name cited above. The plant is related to the Mexican *A. muricata* Humb. & Bonpl., but differs in having unappendaged bracts. Two additional collections belong here:

MEXICO: Coahuila, *Rose 3075;* Buena Vista, *Gregg 349.*

ATRIPLEX DAVIDSONII Standley, N. Amer. Fl. **21**: 57. 1916

This name is proposed for a plant closely related to *A. pacifica* A. Nels. (*A. microcarpa* [Benth.] D. Dietr.) and *A. Coulteri* (Moq.) D. Dietr., but distinguished from both by its dentate leaf blades. In the form of its staminate inflorescence it is intermediate between those two species. The following collections have been examined:

CALIFORNIA: Balboa, *Davidson 2951* (type); Long Beach, *W. F. Parish;* Los Angeles, *Braunton 680;* in 1884, *Nevin;* Colton, *Parry 287.*

ATRIPLEX SONORAE Standley, N. Amer. Fl. **21**: 62. 1916

An ally of the Mexican *A. Barclayana* (Benth.) D. Dietr., but separated by the very different fruiting bracts, these being united only to the middle, their margins green and deeply laciniate, and their sides sharply muricate. The following collections belong here:

SONORA: Empalme, *Rose, Standley, & Russell 12631* (type); Guaymas, *Palmer 671, 672, 673, 674, 677, 690.* SINALOA: Altata, November, 1899, *Brandegee.*

ATRIPLEX POLYCARPA (Torr.) S. Wats. Proc. Amer. Acad. **9**: 117. 1874

Atriplex curvidens Brandeg. Proc. Calif. Acad. II. **2**: 201. 1889.

The type of *A. curvidens*, in the herbarium of the University of California, has been examined by the writer through the kindness of Professor H. M. Hall. It exhibits certain differences from typical *A. polycarpa*, but none that are constant. The stems and bracts are attacked by a fungus, probably a rust, and it is suspected that the specimen is an abnormal one, deformed by the parasite.

ATRIPLEX OBOVATA Moq. Chenop. Enum. 61. 1840

Atriplex Greggii S. Wats. Proc. Amer. Acad. 9: 118. 1874.

When Watson prepared his account of the North American Chenopodiaceae he seems to have overlooked Moquin's name. The type collection of *A. obovata*, obtained by Berlandier, was cited by Watson under his new species *A. Greggii*. *Atriplex Jonesii* Standley (*A. sabulosa* Jones, 1903, not Rouy, 1890) is very close to *A. obovata* and should, perhaps, be regarded as only a form of it. The two seem, however, to have separate ranges.

ATRIPLEX GARDNERI (Moq.) Standley, N. Amer. Fl. 21:66. 1916

Obione Gardneri Moq.; De Candolle, Prodr. 13^2: 114. 1849.
Atriplex Gordoni Hook. Jour. Bot. & Kew Misc. 5: 261. 1853.
Atriplex eremicola Osterhout, Bull. Torrey Club 25: 284. 1898.

The name *Obione Gardneri* has been neglected by all American botanists, possibly because of an impression that the plant was of South American origin. The type locality is given by Moquin as "Ad La Platte," and the collector as Gardner. Hooker, however (*loc. cit.*), pointed out that the specimen was really obtained by Gordon along the Platte River in North America. A fragment of the original collection (*Gordon 251*) in the Gray Herbarium shows that it is the same as the plant described by Osterhout as *Atriplex eremicola*. Since Moquin never changed the specific name first applied, the present writer prefers to maintain it in its original form.

ATRIPLEX CANESCENS (Pursh) Nutt. Gen. 1: 197. 1818

The authority usually given for the above combination is James, but this is incorrect. Nuttall first made the combination *Atriplex canescens* (based on *Calligonum canescens* Pursh), and although he described a different plant at the time he made the transfer of name, he must be credited with the authorship of the binomial.

The species has an unusually wide range and shows very appreciable variation in almost every character. The extensive series of specimens in the National Herbarium indicates, however, that it is impossible to recognize any of the several segregates that have been proposed. Locally some of the forms appear distinct enough, but when the whole series of specimens is examined all shades of intergradient forms are found.

ENDOLEPIS

ENDOLEPIS COVILLEI Standley, N. Amer. Fl. **21**: 73. 1916

Atriplex phyllostegia S. Wats. Proc. Amer. Acad. 9: 108. 1874 (in part). Not *Obione phyllostegia* Torr. 1871.

Endolepis phyllostegia Rydb. Bull. Torrey Club 39: 312. 1912 (in part).

It is remarkable that a plant so distinct and apparently far from rare has been left so long unnamed, but the explanation is found in the fact that Watson confused it with a quite different plant, a true *Atriplex*. The original collection of *Obione phyllostegia* consists of immature and poorly prepared specimens, which, it now appears, are those of a presumably rare species renamed by Jones as *Atriplex Draconis*.* Because of the unsatisfactory material at his disposal, it is not surprising that Watson should have considered the Californian plants the same as *Obione phyllostegia*, and that consequently he should have drawn his description of *Atriplex phyllostegia* from them, chiefly. Probably as a result of this description Jones was led to describe his new species, *Atriplex Draconis*, and Rydberg, later on, to transfer *Atriplex phyllostegia* to the genus *Endolepis*.

SALICORNIA L.

SALICORNIA FRUTICOSA L. Sp. Pl. ed. 2. 5. 1762

Apparently referable here is a specimen from Cameron, Louisiana, collected by W. L. McAtee in 1910 (No. 1916), as well as Nash & Taylor's No. 1122 from Inagua, Bahamas. *S. fruticosa* is a well-known Old World species, occurring in southern Europe, western Asia, Africa, and Polynesia. It is distinguished from *S. perennis* Mill. by the short, conic hairs upon the seeds.

The common perennial *Salicornia* of the Atlantic and Gulf

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* Contr. West. Bot. 8: 40. 1898.

Coasts of North America and of the West Indies was referred by early writers upon American botany to *Salicornia fruticosa* L. In recent years all American botanists, following, apparently, the statements made by Watson in 1874,* have recognized the American plant as a distinct species under the name *S. ambigua* Michx. The present writer, however, can find no character by which to distinguish *S. ambigua* from *S. perennis*, a common Old World plant, and the one which formerly passed as *S. fruticosa* L. Watson stated that the American plant had pubescent seeds and the European glabrous ones, but in making this comparison the European plant he really had in mind was not the Linnaean species, in its proper sense, but a plant now known as *Arthrocnemum glaucum* (Delile) Ung. Sternb.

SALICORNIA DEPRESSA Standley, N. Amer. Fl. 21: 85. 1916

An annual plant of southern California, distinguished from *S. europaea* L., as well as from *S. rubra* A. Nels., by its elongate, prostrate lower branches and small seeds. The following are the only collections seen:

CALIFORNIA: San Diego, 1899, *K. Brandegee* (type); near the Initial Monument, 1898, *K. Brandegee;* Coronado Sand Spit, *Chandler 4011.*

DONDIA Adans.

As treated in the North American Flora, this genus includes twenty species, five of eastern North America, the rest western. Seven species are described as new, three of them known only from Mexico or from barely outside that country. The species of this genus are difficult of determination, and a greater amount of herbarium material, as well as more extensive study in the field, will be necessary to obtain a wholly satisfactory treatment of them, if, indeed, such a treatment is possible. The species described as new seem to the writer to be based upon important differences; certainly they are fully as well marked as most of those heretofore recognized.

DONDIA DEPRESSA (Pursh) Britton; Britt. & Brown, Ill. Fl. 1: 585. 1896

There seem to be no definite characters by which to separate from this *D. calceoliformis* (Hook.) Rydb. and *D. erecta* (S. Wats.)

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* Proc. Amer. Acad. 9: 125. 1874.

A. Nels. The latter is said, by those who know it in the field, to differ strikingly in its prostrate habit, but in the herbarium no technical differences are discoverable, and the habital differences, of course, are not then apparent.

DONDIA MEXICANA Standley, N. Amer. Fl. **21**: 89. 1916

Most closely related to *D. linearis* (Ell.) Heller, a coastal plant of the West Indies and the eastern and southern United States, being distinguished chiefly by the much smaller seed. The following are the only collections known at present:

SAN LUIS POTOSÍ: Hacienda de Angostura, on alkaline plains, *Pringle 3788* (type). TEXAS: El Paso, June 12, 1895, *Plank*.

DONDIA FRUTICOSA (L.) Druce, List Brit. Pl. 60. 1908

Chenopodina Moquini Torr. Pacif. R. R. Rep. 7^3: 18, 1858 (hyponym).
Suaeda intermedia S. Wats. Proc. Amer. Acad. **14**: 296. 1879.
Dondia conferta Small, Bull. N. Y. Bot. Gard. **1**: 280. 1899.
Dondia Moquini A. Nels. Bot. Gaz. **34**: 363. 1902 (hyponym); Abrams, Fl. Los Angeles 131. 1904.
Dondia Wilsonii Millsp. Field Mus. Publ. Bot. **2**: 297. 1909.

The synonyms cited above are only the more important ones based upon North American plants. The most common *Dondia* of the western United States, northern Mexico, the Bahamas and Cuba, the writer is wholly unable to distinguish from the Old World *D. fruticosa*. The West Indian plant seems quite the same as that of the western United States, and the wide distribution in North America seems to make more plausible the specific identity of the Old World and American plants.

The name *D. Moquini*, which has been much used in recent years, is a hyponym, as published by Torrey, for no adequate description was given. Strictly interpreted, the name should be typified by a Cuban specimen cited by Moquin, to which Torrey referred.

DONDIA RAMOSISSIMA Standley, N. Amer. Fl. **21**: 91. 1916

The plants segregated under this name have usually passed as *D. suffrutescens* (S. Wats.) Heller, a species ranging from western Texas and Chihuahua to Arizona, but they are distinguished by the slender, flexuous branches of the inflorescence and the flat leaves, these usually abruptly contracted at the base and apparently petiolate. The following collections belong here:

CALIFORNIA: Saratoga Springs, *Coville & Funston 304, 305;* Indio, June 10, 1907, *V. Bailey;* Calexico, December, 1901, *J. G. Holmes;* Death Valley, *Coville & Funston 193;* near Bakersfield, *Coville & Funston 1233;* Colorado Desert, 1869, *Palmer.* ARIZONA: Lees Ferry, *Nelson 62* (type). LOWER CALIFORNIA: La Paz, *Nelson & Goldman 7484;* Los Angeles Bay, *Palmer 13;* Seven Wells, Sacatón River, *Schoenfeldt 2887;* Gardners Laguna, *Schoenfeldt 2912.*

DONDIA TAXIFOLIA Standley, N. Amer. Fl. **21**: 91. 1916

The material referred here has been included usually in *D. californica* (S .Wats.) Heller. That species, however, has glabrous stems and leaves, while this is copiously pubescent throughout. The following specimens indicate its range:

CALIFORNIA: Newport, *Davidson 2990*; Santa Barbara, *Eastwood 152;* Long Beach, *Braunton 555;* San Nicholas Island, April, 1897, *Trask;* Playa del Rey, *Abrams 2490* (type); Santa Barbara County, *Torrey 461;* Santa Monica, *Nevin 659.*

DONDIA BREVIFOLIA Standley, N. Amer. Fl. **21**: 92. 1916

This, too, is a segregate from *D. californica*, differing in its copious pubescence. From *D. taxifolia* it is distinguished by the small flowers and much shorter leaves. Collections have been seen as follows:

CALIFORNIA: Newport, *Davidson 1779* (type); Balboa, *Davidson 2952;* San Clemente Island, *Trask 37.* LOWER CALIFORNIA: Agua Verde, *Rose 16601.*

UNITED STATES NATIONAL MUSEUM,
WASHINGTON

Phytogeographical notes on the Rocky Mountain Region
VII. Formations in the Subalpine Zone

P. A. RYDBERG

In my Phytogeographical Notes, I have tried to present the distribution of the Rocky Mountain phanerogams viewed from three different standpoints: (1) their zonal distribution, (2) their geographic (provincial) distribution, and (3) their formational distribution. In other words, I have classified the plants: (1) according to the life zone to which they belong; (2) according to their surface distribution, inside as well as outside the Rocky Mountain region; (3) according to the formation to which they belong, i. e., whether they are hydrophytes, or mesophytes, or xerophytes, or any subdivision of these. When I mention formation this should not be taken in a purely ecological sense. In the third paper of the series, "Formations in the Alpine Zone,"* I indicated that I treated the "Formations" purely from a phytogeographical standpoint, and have nowhere treated plant societies, and still two reviewers of my articles (both ecologists) have criticized me for not stating which were the characteristic, the most common, and the secondary species. To do this, when a whole mountain region is treated, is impossible, for in the same class of formations certain species may be the characteristic ones in one locality, while in another they may be only secondary or even lacking altogether.

As shown in the fourth and fifth papers of this series† the vegetation of the Subalpine Zone consists mostly of forests and grasslands. Especially in the Southern Rockies, where the mountain slopes are very steep, another formation is also common, namely, the rock-slides. Where the latter do not exist, the slopes are mostly covered by forest, while the hog-backs and valleys are grasslands.

A. FORESTS

As the forests evidently cover the larger area, they may be treated first. The forest trees are six: *Picea Engelmannii*,

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* Bull. Torrey Club 41: 459–474. 1914.

† Bull. Torrey Club 42: 11–18; 629–632. 1915.

Populus tremuloides, *Abies lasiocarpa*, *Pinus aristata*, *Pinus exilis*, and *Pseudots uga mucronata*, of which the last two really belong to the Montane Zone and extend into the lower part only of the Subalpine Zone. Their relative importance, size, and distribution have been treated before.*

The forest formations of the Subalpine Zone in the Rockies may be divided into more or less defined classes, according to the most characteristic trees found there.

1. SPRUCE-BALSAM FOREST

This formation in the Southern Rockies is mostly found on the northern slopes and along water courses. The predominant tree is the Engelmann spruce, *Picea Engelmannii*. Sometimes it is found in pure stand, sometimes mixed with the subalpine fir or balsam, *Abies lasiocarpa*, occasionally also with the aspen. In the lower part of the zone the red fir, *Pseudotsuga mucronata*, is often added. The following species constitute mainly the flora of the spruce-woods, though several more might be added, especially such as are characteristic of the aspen groves, and occasionally accompany the aspen into the coniferous woods.

The corresponding formation in the Northern Rockies resembles that of the Southern very closely, except that *Abies lasiocarpa* becomes more common on the western side, and on the western slope of the Bitter Root Mountains in places becomes the dominant tree. Lyall's larch, *Larix Lyallii*, and the alpine hemlock, *Hesperopeuce Mertensiana*, are added in the Bitter Root Mountains and the Selkirks, and the former in the main Rockies north of latitude 48° 30′. The red fir, *Pseudotsuga mucronata*, scarcely reaches the subalpine region in the Northern Rockies, but the lodge-pole pine, *Pinus Murrayana*, often enters the lower portion of the zone. As stated in a previous paper, *Picea Engelmannii* and *Abies lasiocarpa* are rare in the Big Horn Mountains, and there often the upper limit of the lodge-pole pine constitutes the timber line.

The undergrowth of the spruce-balsam forest in the Northern Rockies is similár to that of the Southern Rockies. Many of the plants are common to both regions, as seen from the following list. The place of the plants limited to the Southern Rockies is taken by those enumerated below. Species in this and subsequent lists which are marked "†" are limited to the Bitter Root-Selkirk region while those marked "‡" are limited to the Canadian Rockies.

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* Bull. Torrey Club 42: 14–20.

Common to the Southern and Northern Rockies

Trees

Picea Engelmannii
Abies lasiocarpa
(*Populus tremuloides*)
Pseudotsuga mucronata (lower portion of the zone only)

Shrubs

Sorbus scopulina
Lepargyrea canadensis
Pachystima myrsinites
Linnaea americana
Distegia involucrata
Gaultheria humifusa
Vaccinium caespitosum
" *oreophilum*
" *scoparium*

Herbs

Poa crocata
Bromus Richardsonii
Vagnera stellata
Disporum trachycarpum
Lysiella obtusata
Ophrys borealis
" *nephrophylla*
Cytherea bulbosa
Alsine baicalensis
Thalictrum sparsiflorum
Atragene tenuiloba
Parnassia fimbriata
Pectianthia pentandra
Ozomelis stauropetala
Micranthes arguta
Tium alpinum
Atelophragma elegans
Aragallus deflexus
Osmorrhiza obtusa
Ligusticum Porteri
Moneses uniflora
Pyrola chlorantha
" *minor*
" *secunda*
Polemonium delicatum
Pedicularis racemosa
Veronica serpyllifolia
Arnica cordifolia
" *Parryi*
" *pumila*

Restricted to the Southern Rockies

Herbs

Anticlea coloradensis
Limnorchis purpurascens
Aquilegia elegantula
Ozomelis stenopetala
" *Parryi*
Viola neomexicana

Conioselinum scopulorum
" *coloradense*
Androsace pinetorum
Castilleja confusa
Adoxa moschatellina
Valeriana ovata
Senecio amplectans

Restricted to the Northern Rockies

Shrubs

Ribes laxiflorum
‡ " *hudsonianum*
" *petiolare*
Azaliastrum albiflorum
Gaultheria ovatifolia
Chiogenes hispudula
Vaccinium occidentale
" *globulare*
Linnaea longiflora

Herbs

‡*Alsine borealis*
Aquilegia columbiana
" *formosa*
Dentaria rupicola
Parnassia palustris
" *Kotzebuei*
Heuchera glabra
†*Pectianthia Breweri*
‡*Ozomelis trifida*
Atelophragma Forwoodii
Aragallus foliolosus
†*Osmorrhiza Leibergii*
Ligusticum filicinum
Moneses reticulata
Pyrola uliginosa
Aster meritus

2. PINE SLOPES

The characteristic tree of this formation in the Southern Rockies is the bristle-cone pine, *Pinus aristata*, which occupies dry slopes and ridges especially on the southern side of the mountains. It seldom forms a dense forest. Occasionally *Picea Engelmannii* or *Populus tremuloides* has encroached on the pine slopes and then the woods are more dense. In the lower part of the zone the bristle-cone pine is often mixed with the limber pine, *Pinus flexilis*. As *Pinus aristata* seldom makes a close stand but grows scattered on the slopes, the undergrowth is mostly made up of the grass formations, either that of the mountain slopes or that of the hog-backs. Wherever the trees stand close the undergrowth contains more and more of the element found in the more open woods. Some of the more common species are: *Arenaria Fendleri*, *Arnica cordifolia*, *A. pumila*, *A. Parryi*, *Polemonium delicatum*, *Draba streptocarpa*, *D. aureiformis*, *Pseudocymopterus montanus*, *Solidago* *decumbens*, *Poa crocata*, *Festuca saximontana*, *Agropyron Scribneri*, and *Bromus Richardsonii*.

The general feature of the corresponding formation in the Northern Rockies is the same as that just described, but the principal tree of the Southern Rockies, *Pinus aristata*, is not found there. Its place is taken by *Pinus albicaulis*. This tree grows even more scattered and the undergrowth is composed of plants which are still more characteristic of the grass-covered hog-backs. Some of the plants found in the Southern Rockies, as for instance *Pseudocymopterus montanus*, are lacking. *Calamagrostis purpurascens* and *Agropyron latiglume* are rather common. So are also *Xerophyllum tenax* and *X. Douglasii* in places, especially west of the mountains.

3. ASPEN GROVES

The aspen in the Southern Rockies grows mostly on more gentle slopes than the pines, both on the north and south sides of the mountains, especially where the ground is richer and moist. It often takes possession of the ground after the coniferous forest has been destroyed by fire or otherwise. Usually it grows in groves, but sometimes mixed with the spruce, balsam and pines, especially along the edges of woods.

The aspen is not so common in the Northern Rockies, and this is especially true of the Subalpine Zone. In the Montane Zone it grows usually mixed with other species of *Populus*, birches and alders, while in the Subalpine Zone it is found along the edges of the spruce woods, in company with alders and the mountain ash.

The following plants are characteristic of the aspen groves, or else have followed the aspens where they grow mixed with the other trees:

Common to the Southern and Northern Rockies

Trees

Populus tremuloides

Shrubs

Salix brachycarpa
Sorbus scopulina
Distegia involucrata
Vaccinium scoparium

Herbs

Poa crocata
Bromus Richardsonii

Bromus Pumpellianus
Agropyron violaceum
Carex Geyeri
“ *Rossii*
“ *brunnescens*
Allium brevistylum
Vagnera stellata
Iris missouriensis
Disporum trachycarpum
Coeloglossum bracteatum
Alsine baicalensis
Moehringia macrophylla
Atragene tenuiloba
Anemone globosa
Aquilegia caerulea
Arabis Drummondii
Sieversia arizonica
Lupinus parviflorus
“ *pulcherrimus*
Tium alpinum

Atelophragma elegans
Chamaenerion latifolium
Osmorrhiza obtusa
Pyrola uliginosa
“ *minor*
“ *secunda*
Pedicularis racemosa
“ *bracteata*
“ *Grayi*
Veronica serpyllifolia
Campanula petiolata
Oreochrysum Parryi
Erigeron Coulteri
“ *glabellus*
Anaphalis subalpina
Arnica Parryi
“ *pumila*
Achillea lanulosa
Hieracium gracile
Aster Lindleyanus

Restricted to the Southern Rockies

Shrubs

Salix Wolfii
Ribes coloradense

Ribes Wolfii
Sambucus microbotrys

Herbs

Danthonia Parryi
Anticlea coloradensis
Limnorchis purpurascens
Aquilegia elegantula
Draba chrysantha
“ *streptocarpa*
Viola neomexicana
Ligusticum Porteri
Pseudocymopterus montanus

Pseudocymopterus sylvaticus
Conioselinum scopulorum
“ *coloradense*
Castilleja confusa
Polemonium foliosissimum
Valeriana purpurascens
Antennaria viscidula
Senecio amplectens
“ *ambrosioides*

Restricted to the Northern Rockies

Shrubs

‡*Ribes hudsonianum*
" *petiolare*
Ribes laxiflorum
" *glandulosum*

Herbs

Aquilegia columbiana
" *formosa*
Aragallus foliolosus
Hedysarum sulphurascens
Hedysarum Mackenzii
†*Osmorrhiza Leibergii*
Pedicularis contorta
Aster meritus

4. COPSES AND BORDERS OF WOODS

Shrubberies in the Southern Rockies are not common outside of the willow bogs, and the plants gathered together under this heading do not form a distinct formation but a mixture from several, especially of those of the aspen groves, the willow bogs, and the meadows. It consists in reality of the zone of strife between the last one mentioned and the other two. It is therefore not necessary to give a full list of the plants, but only advisable to mention the more common ones.

Copses are more common in the Northern Rockies, especially along the subalpine brooks, where *Alnus sinuata* is the predominant species.

Common to the Southern and Northern Rockies

Shrubs

Salix brachycarpa
Vaccinium scoparium
Distegia involucrata

Herbs

Phleum alpinum
Calamagrostis canadensis
" *Langsdorfii*
Deschampsia atropurpurea
Elymus glaucus
Panicularia nervata
" *pauciflora*
Poa reflexa
" *leptocoma*
" *Olneyi*
Carex Geyeri
" *Rossii*
" *brunnescens*
Veratrum speciosum
Vagnera stellata
Silene Menziesii
Moehringia macrophylla
Draba nitida

Fragaria bracteata
Castilleja rhexifolia
" *lanata*
Erigeron Coulteri
Antennaria anaphaloides
Arnica Parryi
Anaphalis subalpina

Restricted to the Southern Rockies

Shrubs

Salix Wolfii
Acer trifida (Utah)
Sambucus microbotrys

Herbs

Trisetum montanum
Capnoides brachycarpum
Drymocallis fissa
Lathyrus arizonicus
Ligusticella Eastwoodiae
Pseudocymopterus montanus
Oreochrysum Parryi
Cirsium oreophilum
" *Eatonii* (Utah)
" *griseum*

Restricted to the Northern Rockies

Shrubs

‡*Salix Hookeriana*
‡*Ribes glandulosum*
Ribes hudsonianum
Alnus sinuata

Herbs

Silene repens
" *oregana*
Aquilegia columbiana
Sieversia ciliata
Fragaria bracteata
Lupinus monticola
" *caespitosus*
Astragalus spicatus
Homalobus Bourgovii
Hedysarum sulphurescens
" *Mackenzii*
Chaemaenerion angustifolium
" *latifolium*
Senecio pseudaureus
Castilleja Tweedyi
" *lancifolia*

B. GRASSLANDS

The grasslands have been discussed in the fifth paper of the series,* and the grasses were there enumerated. I shall not repeat here the discussion, but merely list the species of plants which enter into the composition of these different formations.

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* Bull. Torrey Club 42: 629–634. 1915.

I. MEADOWS

Common to the Southern and Northern Rockies

Muhlenbergia racemosa
“ *comata*
Phleum pratense
“ *alpinum*
Alopecurus aristulatus
“ *occidentalis*
Agrostis asperifolia
“ *hyemalis*
“ *variabilis*
Calamagrostis Langsdorfii
“ *canadensis*
Deschampsia atropurpurea
“ *curtifolia*
“ *caespitosa*
Trisetum subspicatum
“ *majus*
Graphephorum muticum
Danthonia californica
“ *intermedia*
Poa pratensis
“ *reflexa*
“ *leptocoma*
“ *alpina*
“ *Olneyi*
“ *Vaseyana*
Panicularia nervata
“ *pauciflora*
Hordeum jubatum
Carex pyrenaca
“ *nigricans*
“ *eburnea*
“ *Preslii*
“ *brunnescens*
“ *capillaris*
“ *albonigra*
“ *Reynoldsii*
Carex nova
“ *chalciolepis*
“ *atrata*
Veratrum speciosum
Juncus parous
“ *Mertensianus*
Juncoides parviflorum
“ *intermedium*
Lloydia serotina
Bistorta bistortoides
“ *linearifolia*
Alsine strictiflora
“ *borealis*
“ *longifolia*
“ *calycantha*
Silene Douglasii
Anemone globosa
Ranunculus alismaefolius
“ *micropetalus*
“ *eximius*
“ *alpeophilus*
“ *Eschscholtzii*
Aquilegia caerulea
Aconitum columbianum
“ *insigne*
Thlaspi glaucum
Arabis Drummondii
Clementsia rhodantha
Heuchera parviflora
Leptasea Hirculus
Potentilla filipes
“ *diversifolia*
“ *glaucophylla*
“ *decurrens*
“ *arachnoidea*
Fragaria glauca

Dasiphora fruticosa
Sieversia ciliata
Acomastylis turbinata
Viola bellidifolia
Primula angustifolia
“ *Parryi*
Anthopogon elegans
Amarella scopulorum
“ *plebeia*
“ *strictiflora*
Dasystephana Romanzovii
Phlox Kelseyi
Myosotis alpestris
Veronica Wormskioldii
Valeriana edulis
Campanula petiolata
Solidago oreophila
Aster Canbyi
Erigeron elatior
“ *flagellaris*
“ *glabellus*
Erigeron jucundus
“ *salsuginosus*
“ *superbus*
Antennaria bracteosa
“ *corymbosa*
“ *microphylla*
“ *rosea*
Rydbergia grandiflora
Arnica rhizomata
“ *Rydbergii*
Senecio crassulus
“ *perplexans*
“ *atratus*
“ *pseudaureus*
“ *pauciflorus*
“ *cymbalarioides*
Achillea lanulosa
“ *subalpina*
Hieracium gracile
Taraxacum ammophilum
Agoseris aurantiaca

Restricted to the Southern Rockies

Muhlenbergia Wolfii
Agrostis melaleuca
Deschampsia alpicola
Graphephorum Wolfii
Poa callichroa
“ *pudica*
“ *occidentalis*
“ *tricholepis*
Carex bella
“ *epapillosa*
Veratrum tenuipetalum
Silene Hallii
Sophia purpurascens
Cheirinia oblanceolata
Draba streptocarpa
“ *spectabilis*
Potentilla viridior
Aragallus Parryi
Anthopogon barbellatum
Mertensia pratensis
Besseya plantaginea
Castilleja brunnescens
Campanula Parryi
Pyrrocoma Clementis
Aster griseolus
Erigeron formosissimum
Rydbergia Brandegei
Dugaldia Hoopesii

Arnica macilenta
" *subplumosa*
Senecio pudicus
" *chloranthus*
" *lapathifolius*
Senecio anacletus
" *amplectans*
" *foliosus*
" *multicapitatus*
Agoseris graminifolia

Restricted to the Northern Rockies

Agrostis variabilis
Poa nervosa
Carex ablata
" *montanensis*
" *spectabilis*
Juncoides glabratum
Alsine crassifolia
Silene oregana
" *repens*
" *Douglasii*
‡*Pulsatilla occidentalis*
Ranunculus alismellus
" *saxicola*
" *Suksdorfii*
Aconitum ramosum
‡ " *delphinifolium*
Thlaspi californicum
Heuchera flabellifolia
" *ovalifolia*
Potentilla viridescens
" *glomerata*
" *Vreelandii*
" *flabellifolia*
" *virgultata*
Drymocallis pseudorupestris
Acomastylis sericea
Sieversia ciliata
Lupinus monticola
Trifolium Haydeni
Aragallus viscidulus
" *viscidus*
Epilobium latiusculum
† " *Drummondii*
" *oregonense*
" *anagallidifolium*
Dodecatheon uniflorum
Amarella anisosepala
Phlox alyssifolia
Mertensia paniculata
" *stenoloba*
Pentstemon fruticosum
" *crassifolium*
† " *Lyallii*
Castilleja lutea
" *pallescens*
Adenostegia ramosa
Euphrasia mollis
†*Campanula heterodoxa*
Erigeron politus
Antennaria umbrinella
Arnica tenuis
Senecio megocephalus
" *Hookeri*
" *lugens*
‡*Agoseris pumila*

2. DRY VALLEYS AND BENCHLANDS[*]

Species marked "§" are found in more sandy places; those marked “ Utah ” are restricted within the region of the Southern Rockies to the Wahsatch and Uintah Mountains of Utah.

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[*] For description see Bull. Torrey Bot. Club 42: 632. 1915.

Common to the Southern and Northern Rockies

Stipa Tweedyi
“ *minor*
Poa crocata
“ *longiligula*
“ *lucida*
“ *Buckleyana*
Bromus Porteri
“ *Richardsonii*
“ *polyanthos*
Agropyron violaceum
Elymus simplex
Carex Hepburnii
“ *Engelmannii*
“ *occidentalis*
“ *obtusata*
“ *rupestris*
“ *Rossii*
Eriogonum flavum
“ *umbellatum*
Cerastium scopulorum
“ *strictum*
Alsinopsis Nuttallii (Utah)
Anemone globosa
Pulsatilla ludoviciana
Thlaspi californicum
“ *glaucum*
Draba aureiformis
Ivesia Gordonii
Potentilla filipes
“ *arachnoidea*
Dasiphora fruticosa
§*Gayophytum racemosum*
Phacelia heterophylla
Pentstemon procerus
Campanula petiolata
Leptodactylum pungens
Chrysopsis asperella
Macronema discoideum
Townsendia incana
Antennaria aprica
“ *bracteosa*
“ *corymbosa*
“ *microphylla*
“ *rosea*
Hymenopappus cinereus
Senecio Purshianus
Achillea lanulosa

Restricted to the Southern Rockies

Carex Egglestonii
Eriogonum arcuatum
“ *chloranthum*
“ *neglectum*
Cerastium variabile
§*Arenaria confusa*
“ *globosa*
§*Alsinopsis macrantha*
Lesquerella montana
“ *Wardii* (Utah)
Cheirinia lanceolata
Draba Parryi
“ *streptocarpa*
“ *spectabilis*
“ *luteola*
“ *brachystylis*

Geranium Pattersonii
Pseudopteryxia longiloba (Utah)
Pentstemon caespitosus
Chrysopsis alpicola

Geranium pumila
Erigeron flagellaris
Senecio Nelsonii
" *Jonesii* (Utah)

Restricted to the Northern Rockies

Eriogonum Piperi
" *polyphyllum*
" *heracleoides*
Spraguea multiceps
Arenaria lithophila
† " *salmonensis*
Arabis exilis

Cogswellia montana
Androsace septentrionalis
Phlox alyssifolia
Erigeron Tweedyi
Antennaria albescens
Lygodesmia juncea

3. MOUNTAIN SLOPES*

Common to the Southern and Northern Rockies

Carex pyrenaica
" *nigricans*
" *Geyeri*
" *pseudoscirpoidea*
" *chimaphila*
Juncus Drummondii
" *Parryi*
Juncoides spicatum
Lloydia serotina
Salix petrophila
" *saximontana*
Cerastium scopulorum
" *strictum*
Anemone globosa
Aquilegia coerulea
Draba nitida
" *crassifolia*
" *Parryi*
" *aureiformis*
" *aurea*
Arabis oblanceolata
" *oreophila* (Utah)

Rhodiola integrifolia
Lithophragma bulbifera
Heuchera flavescens
" *parviflora*
Micranthes arnoglossa
" *rhomboidea*
" *brachypus*
Spathularia Vreelandii
Ivesia Gordonii
Potentilla filipes
" *diversifolia*
" *glaucophylla*
" *divisa*
" *quinquefolia*
" *nivea*
" *saximontana*
Sibbaldia procumbens
Acomastylis turbinata
Homalobus humilis
Epilobium clavatum
" *anagallidifolium*
Angelica Rosei (Utah)

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* For discussion see Bull. Torrey Club 42: 632. 1915.

Amarella scopulorum
“ *plebeia*
Dasystephana affinis
Polemonium viscosum (Utah)
Phacelia heterophylla
“ *alpina* (Utah)
“ *sericea*
“ *ciliosa*
Mertensia alpina
Pentstemon procerus
Synthyris pinnatifida (Utah)
“ *laciniata* (Utah)
Castilleja occidentalis
Valeriana edulis
Campanula petiolata
Solidago ciliosa
“ *oreophila*

Aster andinus
“ *frondeus*
“ *apricus*
Erigeron glabellus
Antennaria anaphaloides
“ *aprica*
“ *pulcherrima*
“ *umbrinella*
Arnica Parryi
“ *pumila*
Senecio Nelsonii
“ *crocatus*
“ *cymbalarioides*
Artemisia spithamaea
“ *scopulorum*
“ *saxicola*
Taraxacum scopulorum

Restricted to the Southern Rockies

Carex nubicola
Juncus Hallii
Erythronium parviflorum
Salix pseudolapponicum
Cerastium Earlei
“ *variabile*
“ *oreophilum*
Vahlbergilla Kingi (Utah)
“ *montana*
Anemone zephyra
Aquilegia scopulorum
“ *thalictrifolia*
Sophia purpurascens
Cheirinia oblanceolata
Draba chrysantha
“ *streptocarpa*
“ *spectabilis*
“ *luteola*

Rhodiola polygama
Germania debilis (Utah)
Potentilla modesta (Utah)
“ *tenerrima*
Trifolium Brandegei
“ *Parryi*
Pseudocymopterus Tidestromii (Utah)
Angelica Grayi
Primula angustifolia
Polemonium confertum
“ *mellitum*
“ *Brandegei*
Leptodactylon Nuttallii
Dasystephana Parryi
Phacelia nervosa
Mertensia lateriflora
“ *Bakeri*

Mertensia Parryi
Pentstemon stenosepalus
" *caespitosus*
Besseya alpina
" *plantaginea*
" *Ritteriana*
Castilleja puberula
Pedicularis Parryi
" *scopulorum*
Valeriana acutiloba
Solidago decumbens
Oreochrysum Parryi
Aster griseolus
Machaeranthera Pattersonii
Senecio fedifolius
" *petrocallis*
" *ambrosioides*
Artemisia Pattersonii
" *Parryi*
Agoseris agrestis

Restricted to the Northern Rockies

Xerophyllum tenax
" *Douglasii*
Erythronium obtusum
" *grandiflorum*
Salix Seemannii
" *cascadensis*
" *Fernaldii*
Arenaria lithophila
† " *salmonensis*
Silene Lyallii
" *multicaulis*
‡*Sophia sophioides*
Draba cana
Arabis Lyallii
Heuchera grossularifolia
" *flabellifolia*
Micranthes occidentalis
" *saximontana*
" *Rydbergii*
Spathularia Brunnoniana
Potentilla Vreelandii
" *perdisecta*
Drymocallis pseudorupestris
Acomastylis sericea
Sieversia ciliata
Lupinus caespitosus
Trifolium montanense
Cystium platytropis
Viola adunca
Bupleurum americanum
Amarella propinqua
Dasystephana calycosa
" *monticola*
Phacelia Lyallii
Mertensia paniculata
" *stenoloba*
" *Tweedyi*
Pentstemon montanus
" *pseudohumilis*
" *Tweedyi*
Pedicularis Hallii
Valeriana septentrionalis
Campanula heterodoxa
Oreostemma Haydeni
Townsendia Parryi
Antennaria lanata
‡*Artemisia arctica*
" *elatior*
Agoseris pumila

4. HOG-BACKS*

Common to the Southern and Northern Rockies

Carex Hepburnii
" *Engelmannii*
" *occidentalis*
" *phaenocephala*
" *obtusata*
" *rupestris*
" *Helleri*
" *Rossii*
Eriogonum arcuatum
" *flavum*
" *umbellatum*
Oreobroma pygmaea
Silene acaulis
Cerastium Behringianum
Alsinopsis Nuttallii
" *obtusiloba*
Anemone parviflora
" *tetonensis* (Utah)
" *Drummondii*
Pulsatilla ludoviciana
Smelowskia americana
" *lineariloba*
Draba ventrosa
" *oligosperma*
" *andina*
" *crassa*
" *luteola*
" *aurea*

Rhodiola integrifolia
Ivesia Gordonii
Potentilla divisa
" *nivea*
" *uniflora*
" *saximontana*
" *arachnoidea*
Sibbaldia procumbens
Dasiphora fruticosa var.
Trifolium nanum
Androsace carinata
Gilia globularis
Phlox depressa
" *caespitosa*
Eritrichium elongatum
" *argenteum*
Castilleja occidentalis
Erigeron compositus
" *melanocephalus*
" *simplex*
Antennaria aprica
" *media*
" *sedoides*
" *umbrinella*
Chaenactis alpina
Senecio Purshianus
Artemisia scopulorum
" *spithamaea*

Restricted to the Southern Rockies

Eriogonum chloranthum
" *neglectum*
Paronychia pulvinata

Arenaria Fendleri
Thlaspi coloradense
" *purpurascens*

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* For discussion see Bull. Torrey Club 42: 633. 1915.

Lesquerella parvula
" *Wardii* (Utah)
Cheirinia nivalis
" *radiata*
" *amoena*
Draba sobolifera (Utah)
" *pectinata*
Ivesia utahensis (Utah)
Potentilla tenerrima
" *minutifolia*
" *paucijuga* (Utah)
Trifolium stenolobium
" *bracteolatum*
" *lividum*
" *dasyphyllum*

Aragallus Hallii
" *oreophilus* (Utah)
Oreoxis humilis
" *Bakeri*
" *alpina*
Phlox condensata
Synthyris pinnatifida
" *laciniata*
Chrysopsis alpicola
Erigeron glandulosus
" *pinnatisectus*
Senecio werneriaefolius
" *Holmii*
" *taraxacoides*
" *Soldanella*

Restricted to the Northern Rockies

Eriogonum Piperi
" *polyphyllum*
" *caespitosum*
" *pyrolaefolium*
Oreobroma minima
Anemone Drummondii
Aquilegia Jonesii
‡*Smelowskia lobata*
† " *ovalis*
Pilosella Richardsoniana
†*Draba eurocarpa*
" *densiflora*
" *lonchocarpa*
Arabis Lyallii
†*Phoenicaulis cheiranthoides*
Coniomitella Williamsii
Heuchera ovalifolia
potentilla brevifolia
" *Macounii*
" *wyomingensis*
" *ovina*
Trifolium scariosum

Aragallus alpicola
" *viscidus*
" *viscidulus*
Viola adunca
Pseudocymopterus bipinnatus
Bupleurum purpurascens
Douglasia montana
Phlox costata
" *diapensioides*
Synthyris dissecta
" *reniformis*
Townsendia Parryi
" *florifer*
Oreostemma Haydeni
Erigeron radicatus
" *Scribneri*
" *Tweedyi*
Antennaria acuta
" *mucronata*
" *pulvinata*
‡*Tonestus laceratus*

C. VARIOUS HYDROPHYTIC FORMATIONS

These consist of bogs, brook banks, lakes, ponds, and brooks. In the Subalpine Zone these contain few grasses and no trees. The bogs may be divided into sedge bogs, willow bogs and *Sphagnum* bogs.

1. SEDGE BOGS

The sedge bogs resemble those of the Alpine Zone. These have already been described in a previous paper.*

Common to the Southern and Northern Rockies

Alopecurus aristulatus
Calamagrostis Langsdorfii
Poa reflexa
Phleum alpinum
Panicularia pauciflora
Carex nigricans
" *gymnocrates*
" *disperma*
" *aurea*
" *brunnescens*
" *Reynoldsii*
" *nova*
" *bella*
" *aquatilis*
Scirpus pauciflorus
" *caespitosus*
Eriophorum angustifolium
" *gracile*
Juncus balticus montanus
" *triglumis*
" *castaneus*
" *Mertensianus*
Bistorta bistortoides
" *linearifolia*
" *vivipara*
Alsine longifolia
" *strictiflora*
Alsine laeta
" *crassifolia*
" *calycantha*
Thalictrum alpinus
Ranunculus affinis
Ranunculus eximius
Trollius albiflorus
Aconitum columbianum
Radicula alpina
Parnassia fimbriata
Micranthes arguta
Geum rivale
Epilobium ovatifolium
" *Drummondii*
" *wyomingense*
Hippurus vulgaris
Pyrola uliginosa
Primula Parryi
Anthopogon elegans
Amarella scopulina
" *strictiflora*
Dasystephana Romanzovii
Pleurogyne fontana
Swertia scopulina
" *congesta*
Myosotis alpestris
Veronica americana

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* See Bull. Torrey Club 41: 471, 472, 1914.

Veronica Wormskjoldii
Elephantella groenlandica
Mimulus Langsdorfii
Senecio crassulus
Erigeron salsuginosus

Restricted to the Southern Rockies

Juncus parous
Ranunculus alismaefolius
" *micropetalus*
" *stenolobus*
Caltha rotundifolia
Aconitum Bakeri
" *insigne*
Radicula curvipes
" *Underwoodii*
Epilobium stramineum
Ligusticum Porteri
Senecio atratus
" *lapathifolius*

Restricted to the Northern Rockies

Alopecurus occidentalis
Poa leptocoma
Carex saxatilis
Eriophorum Scheucheri
" *Chamissonis*
‡ " *alpinus*
Tofieldia intermedia
Juncus Regelii
" *nevadensis*
Ranunculus alismellus
" *Suksdorfii*
" *Helleri*
Caltha leptosepala
Aconitum ramosum
‡ " *delphinifolium*
Cardamine umbellata
Cardamine acuminata
Parnassia palustris
" *Kotzebue*
Comarum palustre
Argentina subarctica
‡*Epilobium oregonense*
" *wyomingense*
" *latiusculum*
Pedicularis contorta
" *ctenophora*
" *lunata*
" *Hallii*
" *Canbyi*
" *bracteosa*
" *cystopteridifolia*
Petasites corymbosa

2. WILLOW BOGS

The characteristic vegetation of these consists of shrubby species of *Salix* and *Betula glandulosa*. The herbaceous flora contains most of the plants of the sedge bogs. The shrubs present are the following:

Southern Rockies

Salix Wolfii
" *brachycarpa*
Salix pseudolapponum
" *glaucops*

Salix chlorophylla
Betula glandulosa
Phyllodoce empetriformis
Kalmia microphylla
Distegia involucrata

Northern Rockies

Salix Barkleyi
" *commutata*
" *Tweedyi*
" *pseudomyrsinites*
" *chlorophylla*
Alnus sinuata
Ledum glandulosum
†*Azaliastrum albiflorum*
Phyllodoce glanduliflora
" *empetriformis*
Andromeda polifolia
Vaccinium uliginosum

In the Canadian Rockies quite a number of subarctic willows and other shrubs are added to this flora. These species, which are listed below, grow either in the willow bogs proper or on wet mountain slopes.

Salix Hookeriana
" *myrtillifolia*
" *alaxensis*
" *Barrettiana*
" *Drummondiana*
Salix arbusculoides
" *Seemannii*
" *desertorum*
Ledum groenlandicum
Vaccinium Vitis-Idaea

3. SPHAGNUM BOGS

Sphagnum bogs are exceedingly rare in the Southern Rockies and of very limited extent. The phanerogamic flora, if any, is not different from that of the other bogs. In the northern part of the Northern Rockies, especially in Canada, they are more common. Here, as well as in the northern parts of Montana and Idaho, there are found several phanerogams characteristic of the Hudsonian Zone of the northeast. Among these may be mentioned:

Eriophorum angustifolium
" *Chamissonis*
" *alpinum*
Drosera rotundifolia
" *longifolia*
Thalictrum alpinum
Rubus acaulis
" *arcticus*
" *Chamaemorus*
Oxycoccus palustris
Pinguicula vulgaris

4. BROOK BANKS

Many of the brook banks are lined with willows and *Betula glandulosa* or with sedges. In such cases the flora is practically the same as that of the willow bogs or sedge bogs. In the subalpine regions of the Rockies, we find also another brook bank flora, consisting of herbaceous plants which are neither sedges nor grasses, and which are rarely found in the bogs proper. Brook banks of this type are found mostly where the slope is steep and the valley narrow, so that neither swamps nor grasslands could exist. The characteristic plants of these brook banks are mostly species of *Mertensia. Epilobium* and *Juncoides*, and where it is drier we find *Cirsium*.

Common to Southern and Northern Rockies

Poa reflexa
Panicularia nervata
Calamagrostis canadensis
Juncus balticus montanus
Juncoides parviflorum
" *spicatum*
Delphinium occidentale
Alsine longifolia
" *borealis*
Epilobium ovatum
Epilobium stramineum
" *wyomingense*
Mimulus Langsdorfii
Mertensia pratensis
" *ciliata*
" *viridula*
Veronica americana
Arnica rhizomata
Senecio triangularis

Restricted to the Southern Rockies

Juncoides subcapitatum
Delphinium Barbeyi
" *attenuatum*
Oxypolis Fendleri
Castilleja brunnescens
Cirsium Parryi
" *scopulorum*
" *oreophilum*

Restricted to the Northern Rockies

Poa leptocoma
Juncoides glabratum
‡*Anemone Richardsonii*
Mertensia paniculata
" *stenoloba*
Senecio saliens
Chamaenerion latifolium

In the more open places where the taller herbs have not crowded out the smaller ones, the flora consists of the following species:

Common to Southern and Northern Rockies

Poa alpina
Carex bella
" *calciolepis*
" *atrata*
Scirpus pauciflorus
Juncus triglumis
Juncoides spicatum
Alsine baicalensis
" *laeta*
Alsinopsis propinqua
Sagina saginodes
Ranunculus alpeophilus
Ranunculus Eschscholtzii
Saxifraga cernua
" *debilis*
Chrysosplenium tetrandum
Micranthes arnoglossa
Muscaria delicatula
Androsace subumbellata
" *filiformis*
Condrophylla americana
Pleurogyne fontana
Veronica Wormskjoldii

Restricted to the Southern Rockies

Alsine polygonoides
Condrophylla Fremontii

Restricted to the Northern Rockies

‡*Juncoides arcticum*
‡ " *hyperboreum*
‡ " *arcuatum*
Neiocrene parvifolia
Micranthes Lyallii
" *Brunnonianum*
Hemiera ranunculifolia
Epilobium saximontanum
" *anagallidifolium*
" *clavatum*
Romanzoffia sitchensis
" *Leibergii*

5. LAKES, PONDS AND BROOKS

The purely aquatic flora is not well represented in the Subalpine Zone. It contains practically the same species as are in the Alpine Zone with few additions from the Montane Zone.* The following species belong to this formation:

Common to the Southern and Northern Rockies

Sparganum minimum
" *angustifolium*
Potamogeton alpinus
Catabrosa aquatica
Carex aquatilis
Veronica americana
Utricularia vulgaris
" *minor*
Nymphaea polysepala
Hippuris vulgaris
Lemna gibba
" *minor*

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* Compare discussion in Bull. Torrey Club **41**: 473, 474; **43**: 630.

Restricted to the Northern Rockies

Batrachium confervoides
Veronica scutellata
Lobelia Dortmanna

D. MISCELLANEOUS FORMATIONS

1. ROCK-SLIDES

The rock-slides in the Subalpine Zone* resemble those in the Alpine Zone, and the flora is practically the same with a few additions, as shown by the following lists:

Common to the Southern and Northern Rockies

Selaginella densa
Oxyria digyna
Claytonia megarrhiza
Macronema discoideum

Restricted to the Southern Rockies

Allium Pikeanum
Aquilegia saximontana
Telesonix Jamesii
Heuchera Hallii
Ribes montigenum
Viola biflora
Pseudopteryxia anisata
Primula Parryi
Polemonium Grayanum
" *speciosum*
" *confertum*
" *Brandegei*
Polemonium delicatum
Pentstemon Hallii
" *Harbourii*
" *stenosepalus*
Syntheris plantaginea
Machaeranthera Pattersoni
Senecio Holmei
" *Soldanella*
" *Harbourii*
" *cathamoides*
Senecio invenustus

Restricted to the Northern Rockies

Alsine americana
Telesonix heucheriforme
Ribes parvulum
Pseudopteryxia Hendersonii
Collomia debilis
Polemonium viscosum
Hulsea carnosa
Senecio Fremontii

2. BARE CLIFFS

The flora of the crevices of the bare cliffs is practically the same as that of similar habitats in the alpine region. The species there have already been listed but are again enumerated below.†

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* See Bull. Torrey Club 41: 465. 1914.

† See Bull. Torrey Club 41: 466. 1914.

Common to the Southern and Northern Rockies

Chondrosea Aizoon
Leptasea austromontana
Antiphylla oppositifolia
Oxyria digyna

Restricted to the Southern Rockies

Anticlea coloradensis
Aquilegia saximontana
Polemonium pulcherrimum
Polemonium delicatum
Edwinia macrocalyx (Utah)
Senecio petrocallis

3. TALUS

In many places, under the perpendicular cliffs, there have gathered rather steep slopes of talus. Where this consists of larger rocks, the flora is the same as that of the rock-slides, but where it consists of small fragments and especially where there is a certain moisture, this talus has been taken possession of by certain plants, which can be regarded as forming a distinct formation. The most common of these plants are:

Common to the Southern and Northern Rockies

Carex Geyeri
Juncus Drummondii
" *Parryi*
Alsine laeta
Anemone tetonensis
Epilobium alpinum
" *Hornemannii*

Restricted to the Southern Rockies

Anticlea coloradensis

Restricted to the Northern Rockies

Viola flavovirens

NEW YORK BOTANICAL GARDEN

Fruit bud formation—a criticism

J. H. GOURLEY

(WITH ONE TEXT FIGURE)

Early in 1915, I wrote as follows in Technical Bulletin No. 9, New Hampshire Experiment Station:

> Writers in the eastern United States have commonly made the statement that fruit buds are never axillary in the apple such as occurs in the northwest, yet this method of producing fruit buds in the east is not uncommon. It has been observed by the writer throughout the eastern states on both old and young trees and with many varieties. Whether it has any significance or not, it might be noted that it was more common in the plot fertilized with an excess of nitrogen fertilizer than elsewhere in the orchard. While from a practical standpoint this method of fruit-bud production can be almost ignored, it is well worthy of record.

This position has been controverted by O. Butler in the Bulletin of the Torrey Botanical Club (44: 85–96. 1917), as follows:

> A *fruit branch* is a leader in which the terminal and axillary buds in the upper two thirds or thereabouts of its length become flower buds during the season of its development (PLATES 1, FIG. 2, and 2). The flower buds borne laterally on the leader have been described as formed axillarly by D'Albret and by Gourley, though they are in reality borne terminally on almost sessile spurs (*lambourdes*). A close study during the first season of the buds from which the supposed axillary clusters arise will show that at the close of vegetation the buds are subtended by a rosette of leaves and are not in the axil of a single leaf. The buds are, therefore, terminal on sessile spurs and not axillary, as by definition an axillary bud is a bud borne in the axil of a leaf. Forney is also of this opinion for he states that "it often happens that the eyes of this season's leader become transformed at once into spurs, and flower perfectly the following year." In the apple the development of flower buds on fruit branches is not commonly met with and is said to occur only in very fertile trees, or trees weakened by transplantation or soil exhaustion.

I have recently reëxamined material in our orchards and again find that fruit buds are formed as true axillary buds in abundance on many trees (see FIG. 1). Occasionally short spurs are formed on new growth as I think horticulturists were aware, but in no such abundance as the axillary buds. It is likely that Butler mistook the points of attachment of the larger bud scales for leaf scars as they resemble them somewhat after the blossom cluster has been out a short time. I am led to suggest this explanation as the plates which he shows are illustrations of true axillary flower buds and not spurs as indicated in his text.

Practically the same statement is found in Technical Bulletin No. 10, New Hampshire Experiment Station, by Miss C. A. Black, which adds to the importance of having the matter corrected. In the latter article the author states that "the few scars at the base of this inflorescence indicate that it is really terminal and not axillary." This would indicate that proper material was not at hand for examination, for where axillary flower buds are formed it is impossible to see more than the one large leaf scar and there is no possible point of attachment for other leaves to be found. Her statement that "such buds are few in number and of no vigorous growth" is also an error, although they often do "develop later than the usual terminal flower buds." A wrong interpretation is furthermore given of *pl. 33, f. 2*, of this bulletin. I would consider this figure to represent a two-year-old shoot and not a three-year-old one, for it is common to find a shoot develop from the flower cluster and develop as shown in this figure. In fact two such shoots often are found on the spur with an apple developing also.

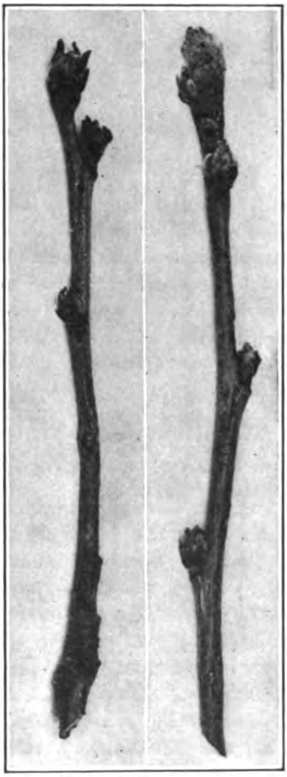

FIG. 1. Axillary flower buds on the Wealthy apple.

In observing wild species of *Pyrus* and *Malus* at the Arnold Arboretum I have found the following list to form fruit buds in the axils of the leaves rather profusely:

Malus pumila Niedzwetzkyana Schneid.
M. pumila apetala Schneid.
M. baccata Borkh.
M. baccata Jackii Rehd.
M. baccata mandshurica Schneid.
M. baccata sanguinea Hort.
M. baccata aurantiaca Hort.
M. Soulardi Britt. (*M. ioensis* × *M. pumila*)

M. astrachanica Dum.-Cours (*M. baccata* × *M. pumila*)
M. Sargentii Rehd.
M. prunifolia Borkh.
M. prunifolia Rinki Rehd.
M. zumi Rehd.
M. micromalus Makino
baccata × *M. spectabilis*)
M. theifera Rehd.
M. Sieboldii Rehd. *calocarpa* Rehd.
M. cerasifera Spach (*M. baccata* × *M. pumila*)
M. floribunda Sieb.
M. Arnoldiana Rehd. (*M. baccata* × *M. floribunda*)
M. spectabilis Borkh.
M. Scheideckeri Zabel (*M. floribunda* × *prunifolia*)
(*M.M. Halliana* Koehne

Pyrus ovoidea Rehd.
P. phaeocarpa Rehd.
P. betulaefolia Bge.
P. Bretschneideri Rehd.

This would indicate a tendency for original species to flower as above described, although in our cultivated varieties of *Malus pumila* Mill. the spur system of flowering is the common method and the axillary formation can be ignored as of no special commercial importance. It is of some interest to note that none of our American species of *Malus*, such as *M. coronaria*, *M. ioensis* and *M. augustifolia*, showed axillary flower buds, although the trees were blooming full. Whether this is always true, I cannot state.

AGRICULTURAL EXPERIMENT STATION,
DURHAM, NEW HAMPSHIRE

INDEX TO AMERICAN BOTANICAL LITERATURE

1914-1917

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the word America being used in the broadest sense.

Reviews, and papers that relate exclusively to forestry, agriculture, horticulture, manufactured products of vegetable origin, or laboratory methods are not included, and no attempt is made to index the literature of bacteriology. An occasional exception is made in favor of some paper appearing in an American periodical which is devoted wholly to botany. Reprints are not mentioned unless they differ from the original in some important particular. If users of the Index will call the attention of the editor to errors or omissions, their kindness will be appreciated.

This Index is reprinted monthly on cards, and furnished in this form to subscribers at the rate of one cent for each card. Selections of cards are not permitted; each subscriber must take all cards published during the term of his subscription. Correspondence relating to the card issue should be addressed to the Treasurer of the Torrey Botanical Club.

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Vol. 44 No. 10

BULLETIN
OF THE
TORREY BOTANICAL CLUB

OCTOBER, 1917

The structure and development of the plant association*

HENRY ALLAN GLEASON

Ecological literature has recently been enriched by the publication of an exceedingly important book (Clements, 3) on the structure and development of vegetation. Not only does the book present a thorough and detailed analysis of vegetation, based on the researches of the author, but it also reviews the theories and summarizes the facts from a vast array of the ecological literature. For all of its contents the working ecologist is grateful, although it is probable that some of the more radical ideas of the author may be accepted reluctantly and that others may be rejected completely.

Certain features of the monograph can scarcely be reconciled with his own by the writer of the present article. Since this paper does not pretend to be either a critique or a review, the writer will not attempt to discuss his objections in detail, but will merely mention what these features are. The chief one of them is the view of Clements, first expressed in 1905 (2), that the unit of vegetation (irrespective of its scope or of the term used to designate it) is an organism. Clements has also so enlarged the scope of the vegetational unit that it includes in his monograph not only a climax but also all the successional series leading to the climax. Thirdly, as a direct result of these two features, he has portrayed the phenomena of vegetation as exceedingly complex, requiring

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* Contribution No. 165 from the Botanical Department of the University of Michigan.

the introduction of several new terms into an already burdened terminology. Lastly, in developing his analytical scheme, several apparent exceptions have been excluded by definition.

Of the actual existence of definite units of vegetation there is no doubt. That these units have describable structure, that they appear, maintain themselves, and eventually disappear are observable facts. That to each of these phenomena a definite or an apparent cause may be assigned is evidenced by almost any piece of recent ecological literature. But the great mass of ecological facts revealed by observation and experiment may be classified in different ways, and from them general principles may be derived which differ widely in their meaning or even in their intelligibility.

There is offered in the following pages a series of general principles in explanation of the usual phenomena of vegetation, based chiefly on observations of the writer in his own field work. Some of these appear almost axiomatic in nature, and none can be supported here by a considerable volume of illustration because of lack of space. In general, they are synthetic rather than analytic in nature, and have been arranged to follow each other as nearly as possible in logical order.

I. THE INDIVIDUALISTIC CONCEPT OF ECOLOGY

1. The life of an individual plant is maintained and transmitted to its progeny by a complex of functions, operating by means of a complex of structures. Vegetation, in its broader aspects, is composed of a number of plant individuals. The development and maintenance of vegetation is therefore merely the resultant of the development and maintenance of the component individuals, and is favored, modified, retarded, or inhibited by all causes which influence the component plants.

According to this view, the phenomena of vegetation depend completely upon the phenomena of the individual. It is in sharp contrast with the view of Clements that the unit of vegetation is an organism, which exhibits a series of functions distinct from those of the individual and within which the individual plants play a part as subsidiary to the whole as that of a single tracheid within a tree.

It is true that various analogies may easily be drawn between a unit of vegetation and an organism, but these analogies are always more apparent than real, and never rise to the rank of homologies. For example, it is obvious that an association may appear on a new area, develop to maturity, and finally disappear, but these phenomena are in nowise comparable to the life history of an individual. A spore of *Rhizopus*, for example, given the proper environment, will grow to maturity and reproduce without the presence of any other living organism. The first pioneer species of an association, on the other hand, will merely reproduce themselves, and maturity of the association will never be reached unless its other species are also present in a neighboring area. Similar exceptions may be taken to all other analogies between the individual and the association, designed to demonstrate the organic entity of the latter.

2. Certain common phenomena of the plant individual, namely, migration of germules, germination, and growth, when performed *en masse* by numerous individuals, may produce visible effects which are worthy of special study and which demand a special terminology. Among these effects may be mentioned the structure of the plant association and of the subsidiary assemblages of plants within it, its space relation to neighboring associations, its development, and its ultimate disappearance.

II. THE ENVIRONMENT

3. The functions of the individual plant demand a proper environment for their operation. Any effective variation in the environment causes a variation in the performance of these functions, and many environmental changes produce also a variation in morphological structure. All these results may be investigated by experimental methods, and fall properly within the domain of morphology and physiology.

4. A fixed environment is probably never necessary to the life of any individual plant, and certainly never to any spermatophyte. Each individual is capable of existing under a variety of environmental conditions; as a simple example, the annual variation in temperature may be mentioned. Also, a fixed environment is not necessary to the life of all the individuals of one species.

The environment of a plant consists of the resultant of all the external factors acting upon it. Therefore individuals of the same species may occupy apparently different habitats and have different associates in different localities. This has been shown by numerous observers, and was definitely mentioned by Cowles in his classic paper of 1901 (4, p. 83). With one environmental factor near the optimum, others may apparently be near the minimum. Thus the tamarack, which in southern Michigan is confined to peat bogs, in Isle Royale occurs even in crevices in vertical rock cliffs.

Restriction of a certain type of environment to one portion of the range of a species may produce geographic variation in its structure, and possibly has a causative relation to the evolution of species. A well-known example is the Douglas fir, with its coastal and inland forms.

5. To state the matter with unnecessarily great refinement, it is probable that no two natural habitats have identical environments, and that no two species make identical environmental demands.

III. MIGRATION AND SELECTION

6. For continuous existence, every species has some form of reproduction. This invariably leads to the establishment of a new individual at some distance from the parent. Whether this distance be great or small, its passage by the germule constitutes migration.

The agents of migration, the devices of the germules which utilize the agent, the distance over which migration is probable, and other phases of the subject have all been frequently discussed in detail, and need no further mention here.

7. Migration may bring the germules into new types of environment, some of which may be effectively different from that of the parent plant. The extent of this effect depends upon the environmental diversity of the region and upon the mobility of the plant. For plants of little mobility, or for more mobile plants in a large area of essentially uniform environment, migration does not normally bring the germules into a new type of habitat. In general, also, there is no selective feature of migration by which the germule is regularly carried into areas of favorable environment.

8. Migration into an area comes only from the surrounding plant population within reach by the usual migration agents. The more mobile immigrants may therefore be drawn from a comparatively large area, while the immobile species must come from contiguous areas. The relation between migration and proximity has already been pointed out by Clements (1, p. 60). In general, for germules of equal mobility, it seems that the number entering any area varies inversely as the square of the distance of the source. This has been demonstrated for short migrations only. It is probable that beyond a distance which might be called the normal migration limit the migration of germules is only accidental. The actual population from which the immigrants of an area may be drawn is therefore a limited one occupying the surrounding region.

Within reasonable limits, depending upon the mobility of the species concerned, the immigrants of neighboring areas are similar, because they are derived from the same surrounding population. This is shown clearly in forest clearings, detached examples of which in the same region are immediately invaded and occupied by the same species. Conversely, the immigrants of widely separated regions are more or less dissimilar, even though their environments may be essentially alike.

9. Of all the immigrants into any area, only those may establish themselves which find in it environmental conditions within the limit of their own environmental demands. The actual mature immigrant population of an area is therefore controlled by two sets of factors: the nature of the surrounding population, determining the species of immigrants as explained in the preceding paragraph, and the environment, selecting the adapted species.

The difficulty of demonstrating the extent of migration and the species involved is at once apparent, since the migrating germules are almost always minute and difficult of detection among the native vegetation. Occasionally the interruption or modification of environmental selection permits the ecesis of unusually large numbers of individuals of a species which would otherwise have been excluded, and affords accordingly an idea of the great number of unsuccessful immigrating germules. Illustrations of this are commonly observed and only a single example need be cited. In the sand-dune region of Illinois, the single passage of a wagon across the sand may bury to a proper depth for germination thousands of seeds of *Cassia Chamaecrista*, so that the course of the wagon is marked during the following summer by parallel lines of the plants. Obviously, migration has been general over the whole area, but environment has prevented ecesis except in this particular path.

10. The germules of the native species of any area are subject to the same environmental selection as those of the immigrants. But, since progeny generally closely resembles parent in structure and function, and accordingly in environmental demands, successive generations of native species and of successful immigrants may occupy an area continuously, unless the environment changes beyond the limits of the species, or the species vary into forms with new environmental demands.

11. In general, and for the average area, opportunities for immigration have existed for so long a time that a complete selection from the surrounding population has been made. Such areas, therefore, show no changes in their population from year to year until the environment or the surrounding population becomes changed. The effects of such changes are discussed in part VII of this paper. When they occur, the resulting change in the component species is at once evident, since migration has continually supplied the area with the germules of hitherto unsuccessful species.

IV. THE ASSOCIATION, ITS SIZE AND BOUNDARIES

12. Whether the population is immigrant or native, it is always subject to the selective action of the environment. In the same limited region, that is, with the same surrounding population, areas of similar environment, whether continuous or detached, are therefore occupied by similar assemblages of species. Such an assemblage is called a plant association.

The term to be applied to such an assemblage, whether association, formation, or something else, and the method of characterizing and distinguishing one from another, are still matters of discussion. The writer believes that the term association is the best designation, and that this term has been applied by a majority of ecological authors to just such assemblages as those defined above.

13. One of the most important features of the environment is the control or modification of the original physical factors by the plant population itself. This action of plant life has been discussed repeatedly and requires no further argument here. As simple examples only, there may be mentioned the reduction of the light for the smaller plants by the crowns of the larger ones, and the modification of soil by the addition of organic substance. This control is in general directly proportional to the density of the plant population. In areas whose physical environment is generally genial and favorable to the development of numerous individuals, the resulting dense vegetation controls to a large degree the original physical factors, and this environmental control is of greater importance than those in the selection of the plant population.

It is at once obvious that, as a result of environmental control, the associated species of even the most limited area do not always enjoy the same environment. Thus the relations of a mature forest tree to light, wind, and soil are very different from those of the shallow-rooted, shade-loving, secondary species beneath it.

The physical factors of the environment generally vary gradually in space. Exceptions to this condition may easily be found in the soil factor, where sharp variations frequently occur, such as the contact of sand with clay at the foot of an advancing dune, or less obviously in the water factor, as on the rocky shore of a lake. Such gradual and progressive variation of environment would normally lead to equally gradual and progressive changes in the vegetation and to the establishment of broad transition zones between adjacent associations, in which the species of both mingle. In most regions of extreme physical environment, occupied by sparse vegetation exerting little environmental control, this condition holds, and the transition from one association to another is just as gradual as the change of environment.[*]

In regions of genial environment and dense vegetation, on the other hand, the nature of the environmental control of two adjacent associations may be, and usually is, very different. Species of one association are then excluded from the margin of the other by environmental control, when the nature of the physical factors alone would permit their immigration. The adjacent associations therefore meet with a narrow transition zone, even though the variation in physical environment from one to the other is gradual.

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[*] This condition has in fact led some students to complain that it was difficult or impossible to distinguish associations in the vegetation of the western states. This would be a sad state of affairs if all vegetation were composed of definite organic entities, but is quite to be expected when vegetation depends upon environmental selection of favored individuals.

In such regions of great environmental control, the boundary between two associations seldom marks the extreme location of suitable physical environment for either, but rather some intermediate position (see also paragraph 25). The removal of either association at one portion of the boundary results accordingly in an immediate extension of the other. This may be seen around many small lakes in Michigan, where a zone of sedge is followed in deeper water by a zone of water lilies. Destruction of the sedge zone in the shallower water is followed by the extension of the lily zone almost or quite to the shore line. The normal landward margin of the water lily association is therefore determined not by depth of water alone, which represents the chief physical environmental variant, but also by the environmental control of the sedge association.

14. Instances may be cited where the sole environmental difference between two adjacent associations lies in the environmental control. This is notably the case with some types of prairie and upland forest in the Middle West. The differentiation of two distinct associations in the same environment is then to be explained chiefly, if not entirely, by developmental conditions, as discussed below under Succession.

15. The line which marks the boundary of the distribution of a species is located at right angles to the direction of the effective environmental variant. Consequently the boundary of the whole assemblage of species constituting the plant association has the same position, whether the variant be purely physical or biotic. Since physical factors generally vary irregularly from place to place, the boundary and shape of an association are also usually irregular.

Symmetry or regularity in the variation of an important environmental factor may however occur. The most conspicuous example is the variation in depth of water or in amount of soil water near the shore of a pond. In such cases, regularity in the environment produces a similar regularity in the arrangement of the associations. When this is conspicuous enough to attract the attention of the observer it is termed zonation.

Zonation of associations is the exception rather than the rule and has no more significance than the usual irregular arrangement. Between the two types there are naturally intermediate stages. Also, irregularity in other conditions affecting the differentiation of associations may operate to disturb their zonation. This has been frequently described or figured (see Harshberger, 8, p. 382, 383) by investigators, generally without a statement of the cause.

16. The area occupied by an association may be large or small, depending on the size of the area available without effective environmental variation. Zoned associations about a pond frequently have dimensions conveniently expressed by meters (see Gates, 5, p. 329), while some forest associations are better measured by the kilometer. The smaller associations are usually composed of fewer species, and are generally of shorter duration than the larger ones. They are the product of the same kind of causes, however, and are no less important in the ecological study of vegetation.

Since associations often tend to extend their area at the expense of others, as discussed below (part VII), the observed size of an association is correlated with its developmental history, and must always be considered from that standpoint.

V. THE STRUCTURE OF THE ASSOCIATION

17. The general tendency of the population of an association to migration tends to produce uniform distribution of each species within it, and consequently uniformity of the association as a whole. This uniformity is one of the most characteristic visible features of the association, and has by some been taken as the basis for a definition of it (6, p. 36). It is easily demonstrable in the small associations and in large ones becomes very impressive. The chief value of the quadrat method of expressing the structure of vegetation depends upon this feature, since a small area can be chosen for intensive study which exhibits faithfully the average structure of the whole association.

Since migration requires time, uniformity of any species is an expression (to be considered in comparison with its mobility) of the length of time it has been in the association, and general uniformity of an association is regularly correlated with its age. As illustration, the uniformity of a forest may be compared with the lack of uniformity in the clearing association which develops soon after lumbering.

18. Excessive seed production is almost universal among plants, and leads to a great competition for the environment. The number of individuals of a species is therefore an expression of the degree of its adaptation to the environment. In the rapid development of an association over a considerable area of ground, as a forest clearing, the most mobile species is naturally represented at first by the greatest number of individuals, irrespective of its adaptation, but as soon as the ground is occupied competition restricts it to its proper proportion.

19. Within an association, minor variations in environment may affect certain susceptible species and not others, and as a result produce minor deviations from the usual uniformity. For example, in an area of woodland in central Illinois, of otherwise uniform structure, a shallow valley is occupied every spring by large numbers of *Floerkea proserpinacoides*. In this case the controlling feature seems to be the greater amount of water in the surface soil during the spring months. For other plants at the same season, and for all plants during the summer and autumn, this feature seems to be without effect.

Recent introduction or slow migration of a species may also produce colonies which interrupt the general uniformity. An instance of the former case has been described (7, p. 520, 521) in the migration of introduced species into the aspen association of northern Michigan. Colonies of the second type are generally caused by the vegetative reproduction of the species, and the resulting compact groups of individuals have been termed families by Clements (2, p. 203).

Among the larger, longer-lived, dominant species, accidents of immigration, such as proximity or a good seed year for one species, may cause the development of minor groups within the association, characterized by a few or only one of its usual dominants.

To such groups Clements has applied the term consocies. Since the individuals of these groups occupy the ground closely from the beginning, they may exclude completely the development of the other dominants of the association until they finally die of old age, when contemporaneous conditions will again decide what species occupy their places. Since dominant species of the same vegetative form have in general similar powers of environmental control, the secondary species beneath a consocies are essentially similar to those elsewhere in the association. For the same reason, the development of minor structural units among the secondaries has little or no relation to the composition of the dominants.

Only rigid experiment and careful observation will refer lack of uniformity accurately to one or another of the causes suggested here.

VI. SCOPE OF THE ASSOCIATION

20. Because of differences in the surrounding plant population, from which the inhabitants of an area are drawn; because of accidents of migration and the time available for it; and because of environmental differences, no two areas need have identical populations, measured by component species and the relative number of individuals of each. This is demonstrable even for areas within a restricted region, and is especially obvious in a comparison of two areas widely separated. For example, no two areas of the beech-maple association near the Biological Station of the University of Michigan show the same vegetational composition, and much greater differences are found when those are compared with the beech-maple forests of southern Michigan, 500 km. away. Still the beech-maple forest has always been interpreted as a single association of wide extent.

Whether any two areas, either contiguous or separated, represent the same plant association, detached examples of the same one, consocies, or different associations, and how much variation of structure may be allowed within an association without affecting its identity, are both purely academic questions, since the association represents merely the coincidence of certain plant individuals and is not an organic entity of itself. While the similarity of vegetation in two detached areas may be striking, it is only an expression of similar environmental conditions and similar surrounding plant population. If they are for convenience described under the same name, this treatment is in no wise comparable to the inclusion of several plant individuals in one species.

VII. SUCCESSION

21. Any change in the association, from any cause whatever, either in the component species or in their relative numbers of individuals, marks a step in the development of vegetation. If this change eventually becomes so great as to involve the replacement of the original association by a different one, the process is known as succession.

Under this definition, the inclusion of any developmental phenomenon under the term succession depends entirely upon the concept of the association held by the investigator. According to general custom, the association is defined broadly enough to permit considerable variation in its structure. Any structural changes within this limit may be referred to minor or periodic environmental changes or to the immigration of relatively unimportant species, and are not considered as succession.

Just as there is a transition zone in space between two contiguous associations, where the species of both mingle, so is there also a transition period between the disappearance of the original association and the complete establishment of the new one, during which relic species of the former and pioneer species of the latter exist side by side. Causes similar to those which decide the width of the transition zone also determine the duration of the transition period. This will be relatively long between associations of similar or slight environmental control and in cases of gradual environmental change, and relatively short between associations of different or great environmental control and in cases of rapid environmental change.

22. Arrival within migration distance of a new population with similar environmental demands (or overlapping ranges of demands) results in fresh immigration and a consequent change in the population of an association. This immigration is limited to those members of the new population which are adjusted to the environmental control of the original association. If these im-

migrants are adapted to the new control in a manner similar to the original secondary species, they behave as secondaries also, and henceforth constitute what has been called the derived element of the population. A noteworthy illustration is found in the prairies of the Middle West, which invariably contain a number of typically forest species, such as *Geranium maculatum* and *Phlox pilosa.*

But if the immigrants are adapted to the original control as seedlings and exert a different sort of control at maturity, they may themselves become dominant. Their establishment then results in the selection of new secondary species, as already discussed (paragraph 9), and the completion of the succession. This process is illustrated in the reëstablishment of forests on the cut-over lands of northern Michigan, where the seedling hardwoods appear as secondary species beneath the dominant aspens. Approaching maturity, they control the light and soil factors of the environment to the ultimate exclusion of the aspens.

Successions of this sort, initiated without environmental change, whether partial or complete, operate over the entire area involved, but will normally be most immediately effective near the margin, because of proximity to the source of immigration.

23. The common cause of succession is an effective change in the environment. This may consist of a change in the physical factors due to inorganic agents, to reaction of the plant upon its environment, due to the cumulative effect of environmental control, or to a combination of the two.

An effective change of environment beyond the range of demand of any individual (or species) causes its death (or extinction). Such effective changes are usually slow in development. In average cases, extinction of a species in an association means death of established plants merely by old age and an increasing death rate by competition among the seedlings. Violent changes, as in the rapid erosion of river banks or the movement of shifting dunes, may actually kill mature plants, but these are comparatively rare. Death of any plant removes its environmental control and may consequently lead to the death of other plants which have depended upon it.

Simultaneously with the death of the old population, the changed environment selects a different new population from the immigrants, and a new association appears.

In regions of sparse vegetation, succession is usually due to changes in the physical environment. In regions of dense population, the same causes are still active, but reaction is usually more rapid and more effective. Physical changes may be retarded by control or reaction, as in the reduction of run-off and erosion by a forest cover, or hastened, as in the weathering of a rock cliff. The effect of slow physical change may also be neutralized for a time by the stability and completeness of the more important environmental control. Thus certain sand hills in Illinois are continually losing a little sand by wind action, but this is sufficiently controlled by the bunch-grass association and no succession occurs.

In successions due to either sort of environmental change, the most mobile species of the invading association normally arrive first and constitute the pioneers. The first species to disappear are those most intimately dependent upon proper control or most narrowly adjusted to the environment. In the climate of the Middle West, these are usually the secondary species. Both for the reason just mentioned and because of their usually longer life, the relic species are more frequently selected from the original dominants.

24. A continued and progressive change in one factor or in a group of factors results in a series of successive associations, which follow each other on the same area of ground. Familiar examples are the decrease in water in the filling of a pond, and the simultaneous increase in humus and decrease in light in the development of a forest.

In any region, similar environmental processes are usually operative in many stations, and since the associations of such successional series must be selected from the same surrounding population, the successive stages of the series in all stations are essentially similar also. Uniformity of successional series may therefore be expected only within regions of similar population and upon areas of similar environmental change. Thus the stages accompanying the filling of a pond by peat formation are not the same in northern and southern Michigan, notwithstanding the similarity in process, because of the difference in surrounding population; and in either region the filling of ponds by peat and by windblown sand is accompanied by different successional series because of the difference in process.

The same environmental processes may not continue in operation long enough to effect the completion of the series. Thus a lagoon in northern Michigan, isolated from a lake by a sand-bar, begins its process of extinction by filling with wind-blown sand. For some time this process of topographic filling is more important than the deposition of organic material, and a series of associations representing a sandy marsh is developed. Later, the establish- of shore thickets on the sand-bar between the lagoon and the lake excludes the sand. Further filling of the pond then depends upon organic deposits, and with the accumulation of peat the associations of a peat bog gradually replace those of the sandy marsh.

Another cause of variation in successional series is found in the accidents of immigration, which may lead to the establishment of several consocies even in the same environment. With all these opportunities for deviation from a simple series, it is easy to understand why carefully constructed successional diagrams are sometimes so complex (Gates, 5, *pl. 39;* Sernander, 9).

25. The duration of an association is merely an expression of the rate of environmental change, irrespective of its cause. Associations of dense vegetation normally hold their place far beyond the period of optimum environment, because of environmental control, competition, and difficulties of immigration, finally yielding only when the environment is approaching the optimum of the succeeding association. This condition was clearly recognized by Cowles (4, p. 79), who termed it "a lagging of effects behind their cumulative causes."

Stability of an association, whether for a long period or a short one, is due to cessation of environmental change, or to the greater effect of environmental control.

26. The location of the initiation of topographic changes is theoretically independent of position within the association. Practically, however, it is almost always at the margin and of such a nature as to produce the environment of the neighboring association. Succession is accordingly usually between adjacent associations. Progressive changes of environment due to physical causes are frequently unilateral, an environmental type appearing on one side of an area, advancing across it, and disappearing on

the other. The accompanying associations therefore lose ground on one side as they gain it on the other, and when the rate of gain and loss are about equal the association as a whole may seem to change its position. Such progressive changes are usually correlated with a regular or symmetrical distribution of environment, so that zonation becomes an epitome of succession. Then the transition zone indicates the location of succession and endures in the same position merely for the transition period.

Succession by reaction begins wherever and whenever effective reaction is completed. This is normally in the oldest part of the association, the location of which may be either central or lateral, depending upon the circumstances of its origin. In either case the result is the same. Proximity, governing the opportunity of immigration, limits the pioneer species in central succession to the most mobile forms. Thus, in the central succession of the black oak association by the mixed forest in Illinois, the most conspicuous pioneer species is the permobile avevectent ***Psedera quinquefolia*** (6, p. 136).

The reaction of an association may also extend beyond its actual margin and produce an effect upon the margin of the contiguous association. If this weakens the environmental control in the latter, an advance of the former association takes place. This is the case in the advance of upland forest on the prairies of the Middle West. Since the sod-forming grasses grow less vigorously in the partial shade of the forest margin, the sod there is less dense and seedlings of forest species can establish themselves. The average rate of advance under these conditions was estimated by the late Professor Burrill at fourteen feet per year.

27. Some associations make no unfavorable reaction on their environment, live under conditions not subject to effective change by the usual topographic agencies of the region, and are not near a different type of vegetation better adapted to the same environment. In the absence of all causes of succession, such associations occupy the area permanently and are called climax. Theoretically, all associations of a region tend to culminate in the establishment of a climax. Many associations, however, occupy their ground so tenaciously that there is little or no observable evidence that they are ever replaced by the association ordinarily considered

to be the climax of that region. Such is the case with the oak-hickory forests of the gravel hills of southern Michigan. Even if the cumulative effect of exceedingly slow physiographic and biotic processes should accomplish this result and lead to their succession by the beech-maple forests, the same fate is not necessarily in store for similar forests of western Iowa, where neither beech nor maple occur. It is always possible, also, that the future may bring an effective change of environment, no indication of which is at present visible. A slight change of rainfall, for example, might lead to the extension of the pine forests of the Rocky Mountains over the high plains of eastern Colorado. The use of the term climax is accordingly largely a matter of convenience, and it will be applied broadly or narrowly, depending on the viewpoint of the ecologist.

Since physiographic processes tend toward stability, successional series tend also toward the establishment of associations of greater duration and the ultimate appearance of a climax. In some cases, as the succession of forest by prairie, this involves a process which is not usual for our climate, or not commonly observed, and which has been termed regressive or retrogressive. In other cases also, an actual reversal of the ordinary direction of succession may be seen, as in the establishment of a pond upon a sand dune (6, p. 111–116). Clements denies the existence of reversed successions, and attempts to exclude described cases by definition (3, p. 145, 146). Measured by the behavior of and effects upon individual plants, however, the processes are precisely the same as in the usual types of succession: a change of environment, the gradual death of the original flora, and the gradual entrance of the new, with the simultaneous revision of environmental control.

28. Great climatic changes in a region, when they occur, are of course productive of proportionately great changes in the vegetation, involving ultimately perhaps the complete replacement of all the original associations by new ones. Without the arrival of a new flora in the region, the change in the original vegetation as the result of climatic change can consist only of the extinction of unadapted species, their replacement wholly or in part by species of recent evolution, and of readjustments in the

plant associations concerned. Such events are so slow that they have never been described from observation, and it is extremely doubtful if the term succession would be applied to them if they were visible.

The actual effect of climatic changes as seen consists of the arrival in the region of a new flora, the establishment of successions between its associations and the original ones, and the gradual replacement of the latter. It is possible that temperature changes have never taken place in the past more rapidly than they are proceeding at present, and that is at a rate too slow to be measured. The effect of such changes, however, are seen in the northward advance of the hardwood forests at the expense of the conifers. As has been repeatedly shown by various authors, the successions involved here are invariably referable to one or another of the causes already discussed in these pages, and no direct effect of a temperature change is visible at all, so far as the structure or succession of associations is concerned.

Great climatic changes, therefore, proceed at a much slower rate than the normal observable causes of succession. Those great successional movements which have marked the development of the flora of the continent through all the climatic and geologic vicissitudes of the epochs, and whose results are now exhibited by the geographical distribution of the flora, are merely the mass effects of small successions, coupled with the evolutionary phenomena of extinction and appearance of species.

SUMMARY

1. All phenomena of vegetation, *i. e.*, of numbers of individuals, depend upon the phenomena of the individual plant.

2. The plant population of any area is determined by environmental selection of immigrants from the surrounding population.

3. Because of similarity of environmental selection and of available sources of immigration, areas of uniform vegetation are developed, known as plant associations.

4. Effective changes in the environment or in the surrounding population may lead to significant changes in the vegetation of an area. If these changes involve the establishment upon it of a new association, the phenomenon is known as succession.

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The development of the spikelets of Zea Mays

PAUL WEATHERWAX

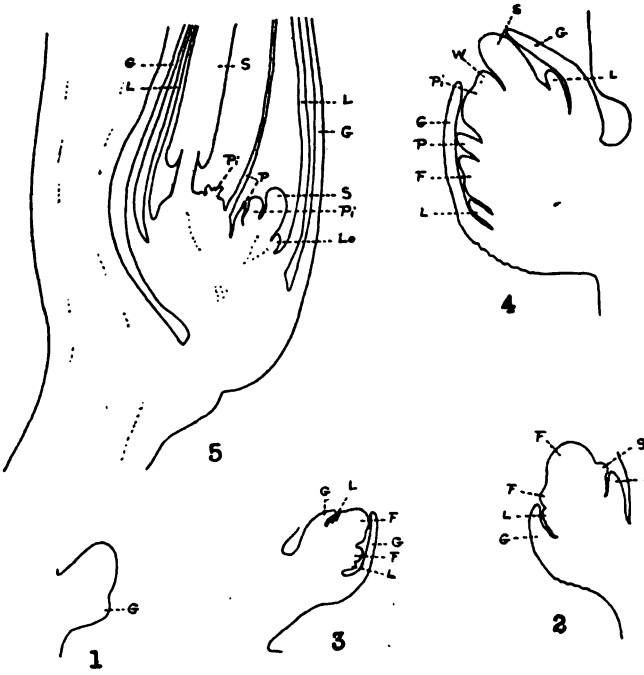
(WITH PLATE 23 AND THIRTY-THREE TEXT FIGURES)

In another publication (8) a description has been given of the flowers of maize, in which the chief emphasis was laid upon the more conspicuous floral features at the time of anthesis. The writer's present purpose is to consider the two types of spikelet from the standpoint of development.

A number of articles have touched upon this subject incidentally, but in no case completely, having in nearly every case something else as their main purpose. True (7) has given a description of the formation of the pistil and the ovule in so far as this is of help in explaining the development of the caryopsis. Poindexter (6) gives a preliminary report on some work of the same kind with corn, but, if the work has ever been completed and published in full, I have no knowledge of it. Guignard's investigations on double fertilization in maize added some information, but his paper (3) naturally does not describe fully the development of the spikelets, and it is not illustrated. Goliński (2), basing his work upon *Poa annua* and *Triticum vulgare*, has given the most comprehensive treatment that I have been able to find of floral development in the grasses; this includes a good account of the literature on the subject up to that time. No reports that I have investigated have taken into account the development of the various rudimentary organs of the spikelets.

During the last four years I have had under observation in one way or another more than a hundred varieties of maize, which have been received from many parts of North and South America and may be considered a fair representation of the species. Of course, not all of these have been examined in detail, but any variety that seemed to be different from the typical in floral development was made the subject of special study until the nature and significance of the variation were determined. Monoecism is the rule in almost all varieties, and the behavior of the floral organs, either functional or rudimentary, is fairly constant. This monoecious form is taken as the type for the purpose of description, and those varieties having a large proportion of perfect flowers, together with the numerous instances of reversion are mentioned only as aids in understanding the typical form.

The development of either of the typical unisexual spikelets of maize can best be described by comparison with a theoretical primitive spikelet such as occurs in some varieties of pod corn, and the like of which is found in several other grasses. This spikelet has two empty glumes and two flowers with four palets. Since the bracts have an alternate arrangement on the rachilla, one flower is a little higher than the other in the spikelet. The higher one, which is on the side of the spikelet toward the rachis, is the older. Each flower has a pistil, three stamens, and two



FIGS. 1–5. Development of the male spikelet, × 60. *G*, glume; *L*, lemma; *F*, flower primordium; *S*, stamen; *P*, palea; *Pi*, pistil; *Lo*, lodicule (in a portion of the section that is not median); *W*, ovary wall.

lodicules. It will be shown that the present maize spikelet, whether male or female, has essentially the structure of this primitive one with some of its parts suppressed.

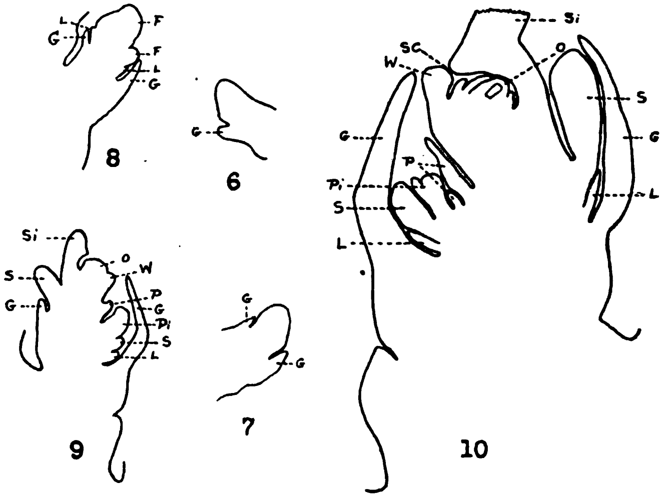
The spikelet primordium makes its appearance as a rounded protuberance on the rachis. The first differentiation to appear is in the formation of the lower glume, and it is soon followed by the upper one (*G*, TEXT-FIGS. 1, 6, 7). The two lemmae arise almost simultaneously with the appearance of the stamens of the upper flower (*L* and *S*, TEXT-FIGS. 2, 3, 8). From the lower side of the undifferentiated part of the spikelet now appears the primordium of the lower flower (*F*, TEXT-FIGS. 3, 4, 8), and the palea of the upper flower soon follows (*P*, TEXT-FIG. 9). The palea of the lower flower appears much later (*P*, TEXT-FIGS. 5, 10). The older flower *seems* to be terminal and the younger one lateral on the rachilla, but it is probably better to consider both flowers lateral branches of this axis, which terminates between the two paleae. This point, however, should be investigated further.

In the development of the flower from its primordium the stamens are first differentiated; these are followed by the lodicules and the part that is left is the primordium of the pistil.

Up to the time of the differentiation of the primordia of the stamen and the pistil, the male and female spikelets have looked very much alike, but now, accompanying the sexual differentiation, there begins a divergence in the appearance of the two. The covering of husks for the female inflorescence, the effects of crowding, etc., bring about further changes until the male and female spikelets finally resemble each other so little that there is a current doubt, or ignorance, at least, of their homologies.

In both flowers of the male spikelet the stamens and lodicules are fully developed, but the development of the pistils is soon arrested, and they disorganize.

The lodicules begin as small protuberances and develop into thick, short, truncated bodies. They are well supplied with vascular tissue and at anthesis are quickly distended to two or three times their former width, very efficiently holding open the spikelet while the filaments of the stamens are elongating. The development of the stamen does not differ very much from that in other grasses. Cross sections of anthers just before the time of the reduction division (PLATE 23, FIG. 4) show the typical parts as described by Goliński, and these, except the epidermis, are practically all absorbed by the time the pollen is mature. For the greater part of the length of the anther its wall consists of merely the epidermis (FIG. 5), but for a short distance at the distal end this wall is reinforced by the mechanical layer (FIG. 6). As a result, it is only at the end of the anther that the loculi coalesce in pairs to form the two "cells," and the opening is a pore formed by the turning back of the edges of a short slit extending along the anther as far as the mechanical tissue goes (FIG. 7). From this pore the pollen grains escape as the wind moves the anther about at the end of the long filament.



FIGS. 6–10. Development of the female spikelet, × 60. *G*, glume; *L*, lemma; *F*, flower primordium; *S*, stamen; *P*, palea; *Pi*, pistil; *Si*, silk; *O*, ovule; *SC*, stylar canal; *W*, wall of ovary.

The reduction division and maturation of the pollen do not furnish very satisfactory material for cytological work. The chromosomes are small and hard to differentiate clearly in the dense cytoplasm. Kuwada (4 and 5) has made a cytological study of a number of varieties and concludes that there is considerable variation in the size and number of the chromosomes. The haploid number in most varieties of sweet corn is found to be twelve, and in other varieties the number is often smaller. To one who is familiar with the plant in its other interesting relations, Kuwada's work, while of much value as far as it goes, is still incomplete. There is yet room for a great deal of interesting and profitable cytological work on varieties that have been inbred for a number of generations, or whose genetic history is otherwise known for a long time. If from such work any regularity can be found for the different varieties, there will be afforded not only a probable basis for improving the present unsatisfactory systematic treatment of the genus but also a new field of study in correlations between cytological behavior and genetic results.

The mature pollen grain is almost spherical; the exine is minutely roughened, and there is a prominent germ pore (FIG. 8). The pore is surrounded by a thickened ring of intine and closed with a plate of tissue which resembles the rest of the wall in structure. The protoplasm is very dense, and careful staining is necessary to make the nuclei visible. The vegetative nucleus is irregular in outline and apparently does not have a definite membrane. The generative nucleus divides before the pollen is shed, forming the two long, slender sperms, which are pointed at the ends and usually crescent-shaped.

It is possible that the development of the abortive pistil varies in some kinds of maize, especially some of the pod varieties that do not produce fruits in the tassel; but there is a remarkable regularity in all that I have examined. The organ develops as in the female flower—which will be described later—up to the time when the ovary wall should begin to be formed, but here it stops. Sometimes it is merely an oval or somewhat constricted protuberance (TEXT-FIG. 12), and sometimes there is a slight indication of the beginning of the ovary wall (*W*, TEXT-FIG. 4). In a few cases a large, conspicuous cell has been seen at about the place where the megaspore mother cell would be expected, but it is impossible to say at this time whether or not it develops this far. The disorganization begins while the epidermis is still intact and soon extends to many or all of the intercellular spaces (TEXT-FIGS. 12–15). The organ is usually completely consumed by the time of the differentiation of the pollen mother cells in the stamens of the same flower, and all that remains at anthesis is a small, shallow cup formed by the epidermis of the base of the aborted organ

(TEXT-FIGS. 5, 15). This is so inconspicuous that it appears that many early investigators, working largely from the systematic standpoint, either did not suspect its presence, or looked for it and failed to find it.

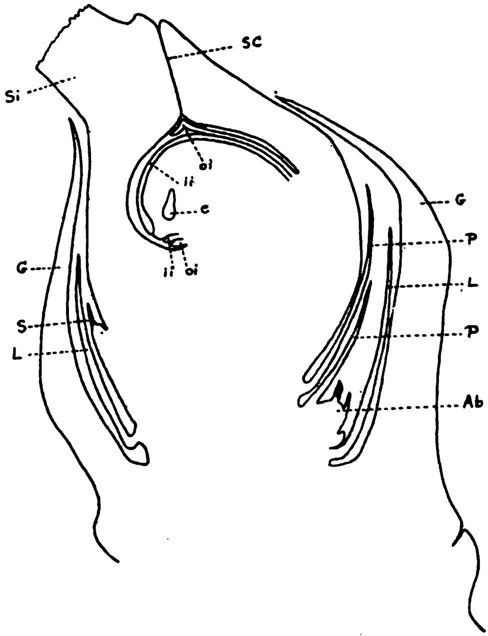
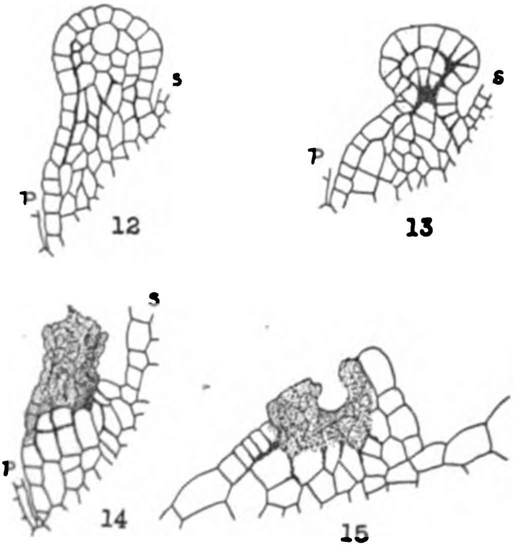


FIG. 11. Longitudinal section of female spikelet, × 60. *G*, glume; *L*, lemma; *P*, palea; *Ab*, aborted flower; *Si*, silk; *SC*, stylar canal; *e*, embryo-sac; *oi*, outer integument; *ii*, inner integument.

The female spikelet is characterized by a suppression of all the essentials of the lower flower and of the stamens of the upper one. Lodicules are present in both flowers, but they are functionless, or, at least, do not serve the same purpose as in the male flower. The only functional organ of the female spikelet is the pistil of the upper flower.

The lodicules of both flowers of the female spikelet are, in early stages, like those of the male flower, but their development is arrested at about the same time as that of the other rudimentary parts. This suppression is not accompanied by disorganization, as in other parts, but the organs merely stop growing and are wholly or partly overtaken by the growth of the surrounding tissues. At anthesis those of the upper flower are seldom visible, while those of the lower flower are relatively conspicuous even when such flower has a functional pistil.

The pistil of the upper flower is not materially different from that of other grasses. Guignard's description is accurate. As he has pointed out (3, p. 43), the pistil seems to be developed from a single carpellary leaf. The duplex structure of the "silk" indicates that it may have resulted from the union of two parts, but there is no direct evidence of this.



Figs. 12–15. Sections showing steps in the decline of the pistil of the male flower. × 60.

After the stamen primordia have been differentiated, the beginning of the pistil is left as a small, rounded protuberance. Near the base of this a ring of tissue begins to grow up and finally arches over to form the ovary wall (*W*, Text-figs. 9, 10, and Plate 23, fig. 3). Ultimately the edges of this come together at the top, but the union is never complete, a small opening to the inside, the stylar canal, being present at the top of the mature ovary (*SC*, Text-figs. 10, 11). In the meantime, a small projection grows up on the adaxial side of the stylar canal, a little distance from the latter, to form the primordium of the "silk."

The "silk," which is peculiar to maize and teosinte, probably owes its unusual structure and exceptional length to the presence of the husks that cover the inflorescence. The writer has previously called this organ a stigma. Since the use of this term has been questioned, a further statement seems appropriate here. The difficulty seems to lie in finding a consistent and generally accepted definition of the word, *stigma*. Some writers, as Strasburger and a number of his students, speak of it as a morphological unit of the pistil, coördinate with the style and the ovary; and others define it as merely that portion of the surface of the style upon which pollen grains may germinate. In dealing with the grasses it is convenient to speak of the feathery part of the filament extending upward from the ovary as the stigma and of the smooth part as the style. Strasburger makes this distinction in his text book. Many other writers, in describing the grasses, recognize the convenience of such a distinction when they speak of the "two or three feathery stigmas." It was not, and is not now, the writer's intention to form a new definition of terms. The point intended is merely this: The corn silk, being compound in structure and plumose and receptive to its base, is the homologue of the "two feathery stigmas" of other grasses. If the common use of the word, *stigma*, in speaking of other grasses is inadvisable, and a consistent nomenclature is devised, the appropriate use of the word, *style*, for the corn silk is conceded.

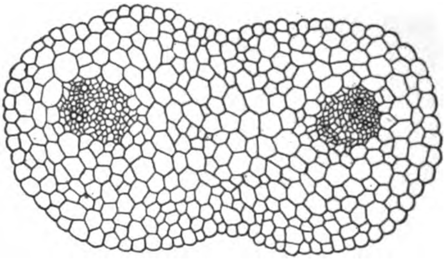
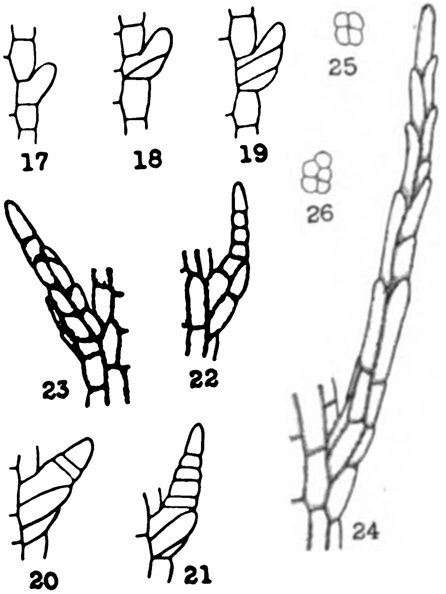


FIG. 16. Transverse section of the silk, × 200.

From the very beginning (PLATE 23, FIG. 3) the silk is divided at the tip, and this division continues into the mature structure, which has already been described (**8**, p. 133). Two strands of vascular tissue traverse the entire length of the organ (TEXT-FIG. 16). Neither in transverse nor in longitudinal section is there any evidence of a tissue morphologically differentiated for the passage of the pollen tube, as has been described for other grasses.

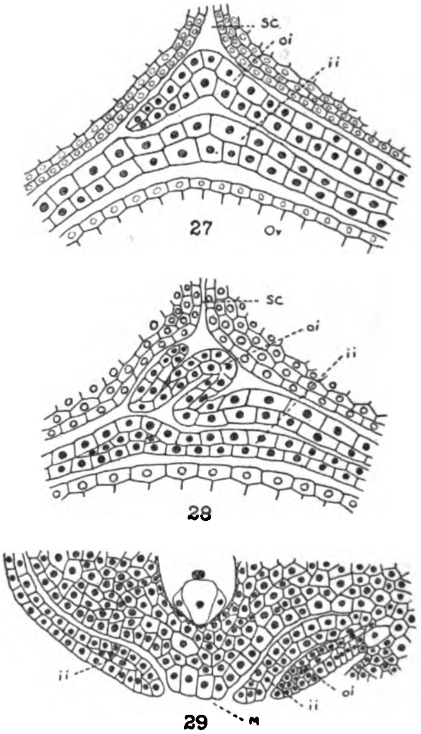
The plumose appearance of the stigma is due to numerous hairs arranged in definite areas. Each hair has its origin in a single epidermal cell (see TEXT-FIGS. 17–24) which divides anticlinally, giving rise to four, or occasionally five, cells. Each of these cells divides transversely a number of times and produces a long filament, the four filaments being loosely attached to each other, leaving an intercellular canal in the middle of the hair. Some of the filaments are longer than others, and, as a result, the hair tapers to a point, where it consists of but a single cell or a single row of cells. The upper ends of many cells of the hair are turned outward, giving the pollen tube easy access to the canal in the middle (TEXT-FIG. 25), through which the tube reaches the main part of the silk. It seems that it is only through these hairs that the pollen tube can gain entrance.



FIGS. 17–24. Steps in the development of a stigma hair. FIGS 25 and 26. Cross sections of stigma hairs. × 200.

The ovary contains a single ovule, which is of a modified campylotropous form. At about the time of the differentiation of the megaspore mother cell, the integuments begin to grow up around the nucellus. The tissues on the adaxial side of the ovule grow so much faster than those on the other side that, at time of the maturity of the embryo sac, that organ, with the tissue immediately surrounding it, has been completely inverted. The ovule is attached for a considerable distance along one side, and no funiculus is present; the embryo sac remains straight, as does the developing embryo. The one part of the outer integument seldom grows further than the top of the ovary, where it forms a folded or wedge-shaped body, closing the stylar canal (TEXT-FIGS. 27, 28). The micropyle is formed by the inner integument, and the nucellus protrudes through it (TEXT-FIG. 29).

The peculiar details of the embryo sac of the grasses have long been know, as Goliński (2) shows in his review of the literature.



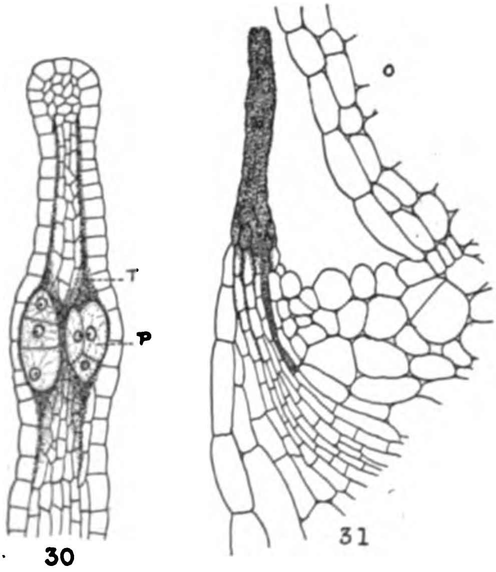
FIGS. 27 and 28. Outer integument and stylar canal. FIG. 29. Micropyle, × 150. *SC*, stylar canal; *oi*, outer integument; *ii*, inner integument; *Ov*, ovule; *M*, micropyle.

In the early stages of development it is not unlike that of many other angiosperms. I have found in the case of *Zea Mays* no evidence of the disorganization of any of the megaspores, and it is probable that all four function as in the group of plants of which *Lilium* is the classical type.

In cytological details I have found nothing in conflict with Guignard's description (3, p. 44) of the mature embryo sac, and only those details will be repeated in which there is some significant peculiarity After the organization of the embryo sac the antipodals divide until there are a large number of cells—sometimes twenty-five or more—some of which have more than one nucleus (PLATE 23, FIG. 1). The polar nuclei do not fuse before the fecundation of the egg.

The abortive stamen of the upper flower of the spikelet develops in the same manner as the functional one of the male spikelet up to the formation of the pollen mother cells; but the loculi are much smaller, and the pollen mother cells fewer than in the normal stamen. Disorganization begins in the tapetal region, and the pollen mother cells are consumed before the epidermis is affected (TEXT-FIG. 30). At anthesis these stamens are small, inconspicuous, disorganized appendages near the base of the pistil (TEXT-FIGS. 11, 31).

The fate of the parts of the lower flower of the female spikelet is similar to that of the homologous aborted parts of the other flowers. TEXT FIG. 33 shows a section of the flower at the time of its highest development, the pistil having already begun to decline. So far as has been determined, no spore mother cells are formed in either the stamens or the pistil. It seems that the decline of all the suppressed organs of the female spikelet begins simultaneously, or nearly so, and the difference in age between those of the upper and those of the lower flower would account for the difference in the degree of development finally reached. These organs of the aborted flower are finally reduced to the condition of the other aborted pistils and stamens, and at anthesis the lodicules are the only prominent parts of the flower. As has already been noted (8, p. 135), the pistil of this flower is known to function with more or less regularity in some varieties.



FIGS. 30 and 31. Disorganization of the stamen in the female flower, × 200. *T*, tapetal region; *P*, pollen mother cells; *O*, ovary.

The cause of this suppression of some organs in all spikelets, resulting, as it does, in monoecism, is unknown. But the fact that variations to the perfect-flowered condition sometimes occur temporarily in strains that have for a long time been monoecious in character, and that these reversions are, in a measure, capable of experimental control, offers a good field for the physiologist. Some of the work of Blaringhen (1) evidently has such facts as

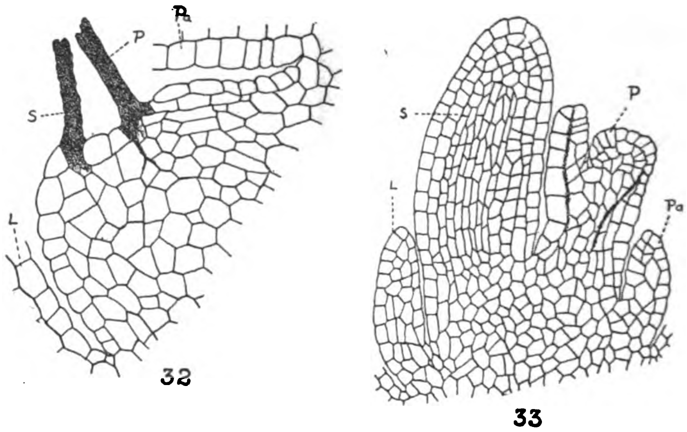


FIG. 32. Lower flower of the female spikelet beginning to be disorganized. × 200. FIG. 33. Aborted flower of the female spikelet at the time of anthesis. × 200. *S*, stamen; *P*, pistil; *L*, lemma; *P*, palea.

these as its basis. It is a noteworthy fact that the organs that are to be suppressed develop normally up to the point where rapid growth and sexual development begin, and then rapidly decline, and this suggests a lack of adequate nutrition. But, before proceeding far on this supposition, we must consider two significant facts: In either the ear or the tassel, there is a strict regularity in the selection of the sex to be suppressed; and it is by starving the whole plant, as when it is grown in a pot in the greenhouse in the winter, that perfect flowers in the tassel are likely to be produced.

SUMMARY

The spikelets of all varieties of maize begin to form two perfect flowers, and monoecism is caused by the suppression of some part or parts of all the flowers. The entire lower flower of the ear spikelet is suppressed, except in a few varieties, and ordinarily only one fruit develops.

In any single flower the development of the stamens is more advanced than that of the pistil; but the pistil of the upper flower of a spikelet is usually more advanced than the stamens of the lower flower.

In the organs in which it occurs, suppression begins at about the time of the differentiation of the spore mother cells in the functional organs.

The aborted stamen of the functional female flower produces microspore mother cells before it begins to decline, and the aborted pistil of the male flower may produce a megaspore mother cell, but the organs of the aborted flower of the female spikelet do not produce spore mother cells.

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Explanation of plate 23

FIG. 1. Embryo sac, *E*, egg; *SS*, synergids; *P*, polar nuclei; *A*, antipodal tissue.

FIG. 2. Another section of the embryo sac shown in Fig. 1.

FIG. 3. Very young pistil, × 60. *S*, one lobe of silk; *W*, beginning of ovary wall.

FIG. 4. Section through the middle of an anther just before the reduction division, × 50.

FIG. 5. Section through the middle of a mature anther, × 50.

FIG. 6. Section from near the distal end of the anther shown in FIG. 5.

FIG. 7. A mature anther, × 10.

FIG. 8. Section of pollen grain, showing germ pore, vegetative nucleus, and the two sperms, × 550.

FIG. 9. Portion of a longitudinal section of a stamen of the female flower, just before disorganization begins, × 200. *E*, epidermis; *T*, tapetal region; *P*, pollen mother cells.

INDEX TO AMERICAN BOTANICAL LITERATURE

1916-1917

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the word America being used in the broadest sense.

Reviews, and papers that relate exclusively to forestry, agriculture, horticulture, manufactured products of vegetable origin, or laboratory methods are not included, and no attempt is made to index the literature of bacteriology. An occasional exception is made in favor of some paper appearing in an American periodical which is devoted wholly to botany. Reprints are not mentioned unless they differ from 'the original in some important particular. If users of the Index will call the attention of the editor to errors or omissions, their kindness will be appreciated.

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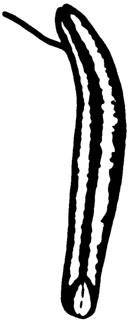

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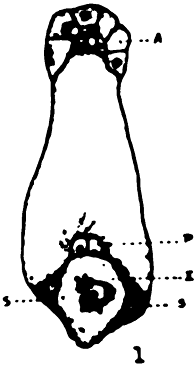

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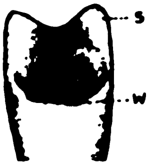

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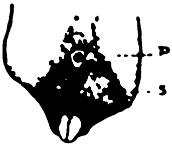

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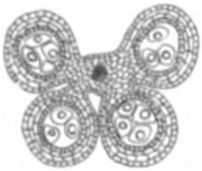

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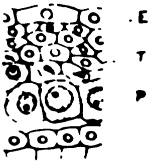

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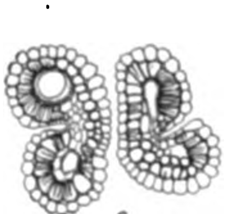

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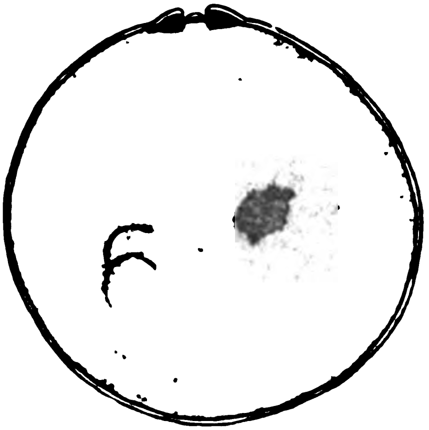

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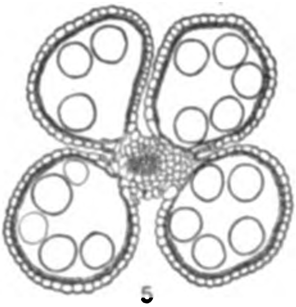

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WEATHERWAX: SPIKELETS OF ZEA MAYS

Vol. 44 No. 11

BULLETIN

OF THE

TORREY BOTANICAL CLUB

NOVEMBER, 1917

Relationship of the genus Kuehneola[*]

J. C. ARTHUR

The genus *Kuehneola* was established by Magnus[†] some twenty years ago to better emphasize the peculiar rust on *Rubus* having white and delicate-walled teliospores, a rust that had previously for a decade been called *Phragmidium albidum*. The colorless telia with their catenulate teliospores, so unlike rusts in general, were placed in the genus *Oidium* by Link in 1824, and in the genus *Torula* by Fries in 1832.

For a brief interval after the fungus was recognized as a rust, and before it was assigned to *Phragmidium*, or its close ally *Kuehneola*, it passed under the name of *Chrysomyxa albida*. In giving this name Julius Kühn,[‡] with his usual thoroughness and insight, clearly set forth the characteristics of both urediniospores and teliospores, pointing out that in the shape and manner of formation of the delicate, cylindrical teliospores, as well as in the absence of paraphyses around the uredinial sorus, and in the general appearance of the urediniospores, there was indicated a closer relationship with *Chrysomyxa* (*Melampsoropsis*) than with *Phragmidium*.

The original *Kuehneola albida* (Kühn) Magn., now better called *K. Uredinis* (Link) Arth., if the earliest specific name is to be adopted (which happens to be one founded upon the telia), is now known to occur on many species of *Rubus* throughout Europe and North America, and another species, *K. andicola* (Diet. & Neg.) Diet., is found in South America on *Rubus geoides* Sm. In 1912 Dietel and the writer added three species to the genus on other rosaceous hosts, and between 1912 and 1914 Butler, Sydow and the writer added eight other species, whose hosts belong to the families Vitaceae, Artocarpaceae, Burseraceae, Anacardiaceae, Verbenaceae and Bignoniaceae. Of all these species the full life history is known for only the first species, *K. Uredinis* on *Rubus* (Rosaceae), and the last one, *K. Markhamiae* (P. Henn.) Syd. on *Markhamia* (Bignoniaceae).

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[*] Presented in part before the American Phytopathological Society at the Columbus meeting, December 29, 1915.

[†] Bot. Centr. 74: 169. 1898.

[‡] Bot. Centr. 16: 154. 1883.

[The BULLETIN for October (44: 463–500. pl. 23) was issued October 1, 1917.]

The last species occurs in German East Africa. A good description is given in Sydow's Monographia Uredinearum (3: 318), but without mentioning the pycnia. These were found on an original specimen in my own herbarium. They are epiphyllous, in small groups opposite the primary uredinia, punctiform, subcuticular, 100–110 μ in diameter, the hymenium flat; ostiolar filaments wanting. The urediniospores are borne singly on pedicels, sparsely echinulate-verrucose, and with three equatorial pores.

It will be seen that the general characters of *K. Uredinis* and *K. Markhamiae* coincide, and the two species can be considered genuine representatives of the genus *Kuehneola*. Although the pycnia of *K. andicola* have not been detected, yet the similarity of the known characters, and the host being a species of *Rubus*, that species can also be included in the genus without hesitancy.

The other recorded species on rosaceous hosts are *K. japonica* Diet., on three species of *Rosa* in Japan, *K. Duchesneae* Arth., on *Duchesnea indica* (Andr.) Focke (*Fragaria indica* Andr.), in North America, and *K. obtusa* (Strauss) Arth., on three or more species of *Potentilla*, in Europe, and on *P. canadensis* L. in North America. No specimen of the species on *Rosa* has been seen by the writer, but the description, for telia only, appears to warrant its inclusion under *Kuehneola*.

In studying the species on *Potentilla*, or two species as maintained by some uredinologists, it was brought out some time since that the relationship with species of *Kuehneola* on *Rubus* is not as close as had been assumed. The matter was especially brought to my attention by Dr. F. D. Fromme, while a member of my laboratory force, and has since been considerably elucidated. Recently the statement of Dietel,* made a number of years since, was brought to mind, and as he has covered the chief item in question very succinctly, I can not do better than present his words in English form. Dietel says: "The so-called teliospores of *Kuehneola* are spore-chains, series of one-celled single spores, which are successively abstricted one after the other from the apex of a common hypha, and remain united fast with one another." This statement by Dietel applies to the members of the genus *Kuehneola* as represented by the forms on *Rubus* and *Markhamia*, but not to the forms on *Potentilla* and *Duchesnea* that the writer placed under that genus, although there is much similarity in appearance between the two. The latter have the teliospores distinctly stalked. They are morphologically in regard to their septation like the teliospores of *Phragmidium*, under which genus they are usually placed, but have single, apically placed pores in each cell, and the spores are smooth. For such forms I propose the following new genus, named in honor of Dr. F. D. Fromme, professor of botany in the Virginia Polytechnic Institute, whose clear thinking and cogent reasoning have much enriched botanical science.

Frommea gen. nov.

Cycle of development includes pycnia, primary and secondary uredinia and telia; autoecious. Pycnia subcuticular, other sori subepidermal.

Pycnia with flat hymenium and without ostiolar filaments.

Uredinia with few or no paraphyses, the urediniospores borne singly on pedicels, pale, and with pores indistinct, usually equatorial.

Telia without paraphyses, the teliospores free, pedicelled, serially several-celled, rarely one-celled, colored, the wall smooth, the pores single and apically placed in each cell.

Type *Uredo obtusa* Strauss, on *Tormentilla erecta*.

Frommea obtusa (Strauss) comb. nov. (*Uredo obtusa* Strauss, *Phragmidium Tormentillae* Fckl., *P. Potentillae-canadensis*

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* Ann. Myc. 10: 205. 1912.

Diet., *Kuehneola obtusa* Arth.), on *Potentilla sylvestris* (*P. Tormentillae*, *Tormentilla erecta*), *P. procumbens*, *P. mixta*, *P. reptans*, *P. canadensis*, Europe and North America.

In Sydow's Monographia Uredinearum (3: 105, 106), where the primary uredinia are described as aecia, the European and American forms are assigned to separate species distinguished by the different number of cells in the teliospores, but in the examination of a large number of collections of each no such difference has been detected. The description of the type species by Strauss is that of the telia, and his illustration shows a teliospore, although Strauss placed his species under Uredo.

Frommea Duchesneae (Arth.) comb. nov. (*Kuehneola Duchesneae* Arth., *Phragmidium Duchesneae* Syd.), on *Duchesnea indica*, North America.

Frommea Polylepidis sp. nov., on *Polylepis* sp., Corazon, Ecuador, October, 1891, *G. Lagerheim.*

Uredinia hypophyllous, scattered, round or oblong, 80–160 μ across, soon naked, somewhat pulverulent, dirty white, ruptured epidermis evident; paraphyses none, urediniospores obovoid or ellipsoid, 10–16 by 19–25 μ; wall light yellow to colorless, 1–2 μ thick, evenly and moderately verrucose-echinulate, the pores obscure.

Telia unknown.

The genus *Frommea* differs from *Phragmidium*, not only in having nearly or quite smooth teliospores, with one apical pore in each cell, instead of tuberculate teliospores with more than one pore and lateral in each cell, but also in possessing no aecia proper with catenulate spores, but instead having primary uredinia with pedicellate spores. The primary uredinia are circinnate about the pycnia, epiphyllous, large and much resembling in gross appearance the caeoma of a *Phragmidium.*

The next group of species to be considered consists of the two species on Malvaceae, placed by the writer under *Kuehneola* in 1912 (N. Am. Flora 7: 187), and accepted as such by subsequent writers. The discovery of the telia in this group was made in March, 1911, by Mr. C. R. Orton, then a member of the laboratory force, now assistant professor of botany in the Pennsylvania State College, who found them on *Malvaviscus Drummondii* T. &

G., collected at Austin, Texas, October 31, 1909, *Heald & Wolf 372*. Since then they have been found on two collections of *Malvaviscus*, *M. arboreus* and *M. mollis*, from Guatemala. These three collections are the only ones yet known to show telia for *K. malvicola*.

All three collections show abundance of the telia, which agree in their appearance and form with the published description. The long filiform spore chains do not readily separate into single cells, even after germination. They spread apart, however, even to the hymenial point of attachment in the sorus, showing that there is no tendency to lateral agglutination. The walls are distinctly cinnamon-brown, and in this character, as well as the negative fact that pycnia are unknown, the species fails to accord with the species of *Kuehneola* on *Rubus* and *Markhamia*, but the agreement is so marked in the more essential characters, that the species may for the present be considered correctly placed under the genus *Kuehneola*.

When telia on *Gossypium* were found by Mr. Orton in May, 1911, it was natural to suppose they would fall readily into the same genus as the other malvaceous form had done, especially as the characters of the uredinium were practically in agreement. Both species have delicate, uniseriate teliospores. In the *Gossypium* rust, however, the spores are adherent laterally, and the end cells of all the spore chains fall away readily, producing a short columnar telium that becomes pulverulent at the extremity. In the form of the telium it simulates that of *Cronartium*, only being short, scarcely higher than broad, instead of being excessively long. The teliospores are colorless, not tinted as in *K. malvicola*.

The telia of the *Gossypium* rust in color, habit of spores, and general form, agree well with those of *Cerotelium*, the only fully recognized species of which, *C. Canavaliae*, is on a fabaceous host. The uredinia of the *Gossypium* and *Canavalia* rusts are not unlike, except that the former has delicate, peripheral paraphyses, imbricated over the sorus, most readily seen when still unopened while the latter has a delicate peridium of polygonal cells, also most readily seen in the unopened sorus. In both cases the uredinial envelope breaks away and becomes more or less evanescent after the sorus opens.

There remain the following species assigned to *Kuehneola:* *K. Vitis* (Butl.) Syd. (Vitaceae), *K. Butleri* Syd. and *K. aliena* Syd. & Butl. (both Anacardiaceae), *K. Fici* Butl. (Artocarpaceae), and *K. peregrina* Syd. & Butl. (Verbenaceae), for none of which has the writer seen an authentic collection. In the case of *K. Fici* the writer has already followed the lead of Butler[*] and Sydow[†] and accepted the statement made by Butler that the uredinial stage so common on the cultivated fig and other species of *Ficus* in the tropics is identical with the form associated with telia occurring in India on *Ficus tomentosa*, and has so listed collections from the West Indies.[‡] Carefully reviewing the excellent description and figures given by Butler, it seems that the *Ficus* rust has a telial structure essentially the same as that of the *Gossypium* rust, and should be assigned to the same genus. The same reason holds for a similar treatment of *K. Vitis* and *K. Butleri*. In the case of *K. aliena* and *K. peregrina* no paraphyses for the uredinium are described, but in all other respects the descriptions indicate a similar rust. Whether in this case paraphyses are entirely absent, or only to be seen by special manipulation, the writer has no way of ascertaining.

By this interpretation of generic characters only five species remain in the genus *Kuehneola*, out of the dozen or more which have heretofore been assigned to it. They are three with hosts in Rosaceae (*K. Uredinis*, *K. andicola*, *K. japonica*), one in Bignoniaceae (*K. Markhamiae*), and one in Malvaceae (*K. malvicola*). The greatest importance is here attached to the structure of the telium, less to the urediniospores, and least to the absence or presence of peridium or paraphyses in the uredinium.

This last item indicates an entire change of opinion by the writer regarding the value of characters drawn from the protective structures of the uredinium for generic diagnoses. A strong factor in founding the genera *Physopella* and *Bubakia* in 1906[§] was the belief that the nature of the paraphyses or peridium, or their absence, was of high generic value, and the same opinion has more than once been reaffirmed.[||] Recent studies of rusts with indehiscent, lenticular telia of the *Schroeteriaster-Phakopsora* appearance have entirely reversed this view. It has been found that with all other characters in essential agreement, the uredinium may have a membranous peridium opening by a central pore (e. g., *Phakopsora punctiformis* Diet.), or imbricated paraphyses united at their bases forming a pseudo-peridium opening by a central pore (e. g., *Phakopsora Pachyrhizi* Syd.), or a circle of hyphoid or incurved paraphyses often not higher than the spore mass (e. g., *Phakopsora Vitis* Syd.), or neither peridium nor paraphyses (e. g., *Bubakia Crotonis* Arth.).

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[*] Ann. Myc. **12**: 76. 1912.

[†] Monog. Ured. **3**: 323. 1914.

[‡] Mycol. **8**: 174. 1916.

[§] Result. Sci. Congr. Bot. Vienne 338.

[||] Mycol. **7**: 173. 1915; **9**: 59. 1917.

The same situation appears to prevail in the genus *Cronartium*, as indicated by recent studies not yet published of tropical American material. The same appears to be true of the expanded genus *Cerotelium* and to some extent of the contracted genus *Kuehneola*, as here outlined. These four genera appear to be closely related, having a like development of the uredinium with its several forms of protective envelope or none, and a characteristic telium for each. Only in *Kuehneola* has the life cycle for some species been completed, and when this is done for the other genera, of course it is possible that some further shifting or emendation may be required.

The following outline is presented to bring together in closer view the several groups of rusts considered in this paper. All short-cycle forms are excluded from consideration. The type species of the genus is given in each instance, and also the type species of genera reduced to synonymy. Under *Cerotelium*, *Kuehneola*, and *Frommea*, all species known to the writer which may be correctly placed under these genera, are here listed, but under *Phakopsora* and *Cronartium* only such species are given as are considered especially illustrative, or call for transfer from other genera. Other species heretofore published and accepted under *Phakopsora* and *Cronartium*, possessing known telia, such as given in the third volume of Sydow's Monographia Uredinearum, have not been listed.

Only in a few instances is it possible to assign forms to their respective genera when only the uredinia are known. The attempts to do so by the Sydows (*Kuehneola Garugae* and *Phakopsora Juelii*), as well as those by the writer under the genus *Physopella*

(*P. Maclurae*, *P. Cherimoliae*, and *P. Artocarpi*), must be considered premature and exceedingly hazardous. Many forms described under *Uredo*, which almost certainly belong under one of the genera here presented, must await the discovery of telia for further assortment.

UREDINACEAE (MELAMPSORACEAE)

Telia laterally expanded, lenticular or discoid, indehiscent, the teliospores one-celled, catenulate with few spores in a chain, compacted; uredinia with delicate, cellular peridium, with peripheral, free or imbricated paraphyses or neither, the urediniospores sessile, apparently produced in chains with one spore maturing at a time and falling away before the next one enlarges.......PHAKOPSORA

PHAKOPSORA PUNCTIFORMIS (Barcl. & Diet.) Diet. (type of *Phakopsora*), on *Galium Aparine* (Rubiaceae), India.

Phakopsora alpina (Schröt.) comb. nov. (*Uromyces alpinus* Schröt., type of *Schroeteriaster*), on *Rumex alpinus* (Polygonaceae), eastern Europe.

PHAKOPSORA VITIS (Thüm.) Syd. (type of *Physopella*), on *Parthenocissus* and *Vitis* spp. (Vitaceae), Japan, possibly including all forms in tropical America where no teliospores have yet been found.

Phakopsora fenestrala (Arth.) comb. nov. (*Uredo fenestrala* Arth.), on *Phyllanthus distichus*, *P. grandifolius* and *P. Niruri* (Euphorbiaceae), Porto Rico.

Phakopsora Crotonis (Burr.) comb. nov. (*Schroeteriaster Crotonis* Diet., type of *Bubakia*), on *Croton* and *Crotonopsis* spp. (Euphorbiaceae), North America.

Phakopsora mexicana (Arth.) comb. nov. (*Bubakia mexicana* Arth., *Schroeteriaster mexicanus* Syd.), on *Croton* spp. (Euphorbiaceae), Mexico.

Phakopsora argentinensis (Speg.) comb. nov. (*Schroeteriaster argentinensis* Syd.), on *Croton* sp. (Euphorbiaceae), South America.

Phakopsora stratosa (Cooke) comb. nov. (*Schroeteriaster stratosus* Syd.), on *Croton sylvaticus* (Euphorbiaceae), Southern Africa.

Phakopsora Glochidii (Syd.) comb. nov. (*Schroeteriaster Glochidii* Syd.), on *Glochidium zeylanicum* (Euphorbiaceae), Formosa.

Phakopsora Brideliae (Koord.) comb. nov. (*Uredo Brideliae* Koord., *Schroeteriaster cingens* Syd.), on *Bridelia* spp. (Euphorbiaceae), Philippines, Java, India.

Phakopsora Meibomiae (Arth.) comb. nov. (*Physopella Meibomiae* Arth.), on *Meibomia* spp. (Fabaceae), West Indies.

Phakopsora Vignae (Bres.) comb. nov. (*Uredo Vignae* Bres., *Physopella concors* Arth.), on *Vigna lutea* (host of type), *Phaseolus lunatus*, *Dolichos Lablab*, *Teramnus uncinatus* (Fabaceae), West Indies. The teliospores of this species are not yet known.

Phakopsora Crotalariae (Diet.) comb. nov. (*Uredo Crotalariae* Diet.), on *Crotalaria* sp. (Fabaceae), Rio Janeiro. The telia were found on a part of the original collection, made by E. Ule at Copacabana, on the bay of Rio de Janeiro, Brazil, in August, 1897. They are subepidermal, inconspicuous, lenticular, about 4 or 5 spores deep, the spores compact, angular, about 10–15 μ in diameter, the wall 1.5 μ thick, cinnamon-brown. The uredinia have imbricated paraphyses and urediniospores very similar in size and form to those of *Phakopsora Vignae*.

Phakopsora Aeschynomenis (Arth.) comb. nov. (*Uredo Aeschynomenis* Arth.), on *Aeschynomene* spp. (Fabaceae), Mexico, West Indies and South America. The teliospores are not yet known.

Telia erect, verruciform, not much longer than broad, erumpent, somewhat waxy, becoming pulverulent at the surface, the teliospores one-celled, catenulate with few spores in a chain, the terminal spores readily separating upon germination; uredinia as in the preceding. . . . . . CEROTELIUM

CEROTELIUM CANAVALIAE Arth. (type of *Cerotelium*), on *Canavalia ensiformis* and *C. gladiata* (Fabaceae), Porto Rico.

Cerotelium Fici (Cast.) comb. nov. (*Uredo Fici* Cast., *Uredo ficina* Juel, *Physopella Fici* Arth., *Kuehneola Fici* Butl.), on *Ficus* spp., *Toxylon pomiferum*, *Broussonetia papyrifera*, *Morus indica* (Artocarpaceae), in all tropical regions, chiefly as uredinia.

Cerotelium Vitis (Butl.) comb. nov. (*Chrysomyxa Vitis* Butl., *Kuehneola Vitis* Syd.), on *Ampelocissus latifolia* (Vitaceae), India.

Cerotelium Gossypii (Lagerh.) comb. nov. (*Uredo Gossypii* Lagerh., *Kuehneola Gossypii* Arth.), on *Gossypium* spp. (Malvaceae), tropical Asia and America.

Cerotelium peregrinum (Syd. & Butl.) comb. nov. (*Kuehneola peregrina* Syd. & Butl.), on *Clerodendron* sp. (Verbenaceae), India.

Cerotelium Lanneae (Höhn.) comb. nov. (*Uredo Lanneae* Höhn., *Kuehneola Butleri* Syd.), on *Odina Wodier* (Anacardiaceae), India and Java.

Cerotelium Spondiadis (Petch) comb. nov. (*Uredo Spondiadis* Petch, *Kuehneola aliena* Syd. & Butl.), on *Spondias mangifera* (Anacardiaceae), India.

Cerotelium Eviae (Rac.) comb. nov. (*Dietelia Eviae* Rac.), on *Spondias* (*Evia*) spp. (Anacardiaceae), Java. It is possible that this and the preceding species, *C. Spondiadis*, may be identical.

Telia erect, filiform, erumpent, waxy, becoming corneous, the teliospores one-celled, in long, indistinguishable chains, not separating upon germination; uredinia as in the preceding..CRONARTIUM

CRONARTIUM FLACCIDUM (A. & S.) Wint. (type of *Cronartium*), on *Asclepias* spp., etc. (Asclepiadaceae, etc.), Europe and Japan.

CRONARTIUM BYRSONIMATIS P. Henn., on *Brysonima coccolobifolia* (Malpighiaceae), South America, a species with uredinia having imbricated paraphyses.

CRONARTIUM ZIZYPHI (Pat.) Syd. & Butl., on *Zizyphus* sp. (Rhamnaceae), India, a species with uredinia having imbricated paraphyses.

Telia erumpent, velvety, the teliospores one-celled, catenulate with many spores in spreading, free chains; uredinia apparently as in the preceding, but the paraphyses hyphoid, inconspicuous, or none; pycnia accompanying primary uredinia. KUEHNEOLA

KUEHNEOLA UREDINIS (Link) Arth. (type of *Kuehneola*), on *Rubus* spp. (Rosaceae), North America, Europe, and Southern Africa.

KUEHNEOLA ANDICOLA (Diet. & Neg.) Diet., on *Rubus geoides* (Rosaceae), South America.

KUEHNEOLA JAPONICA Diet., on *Rosa* spp. (Rosaceae), Japan.

KUEHNEOLA MARKHAMIAE (P. Henn.) Syd., on *Markhamia* sp. (Bignoniaceae), East Africa.

KUEHNEOLA MALVICOLA Arth., on *Malvaviscus* and *Hibiscus* spp. (Malvaceae), tropical America.

AECIDIACEAE (PUCCINIACEAE)

Telia erumpent, the teliospores free, pedicellate, cells uniseriate or rarely one, the pores one in each cell and placed apically; uredinia both primary and secondary, no paraphyses or peridium with the former, inconspicuous peripheral paraphyses with the latter, or none; pycnia accompanying primary uredinia....FROMMEA

FROMMEA OBTUSA (Strauss) Arth., on *Potentilla* spp. (Rosaceae), North America and Europe.

FROMMEA DUCHESNEAE Arth., on *Duchesnea indica* (Rosaceae), North America.

FROMMEA POLYLEPIDIS Arth., on *Polylepis* sp. (Rosaceae), South America.

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The guavas of the Hawaiian Islands

VAUGHAN MACCAUGHEY

The guavas comprise a valuable and widely distributed genus (*Psidium* L.) of tropical and subtropical fruit trees and shrubs. They are indigenous to America, but numerous species are now thoroughly established in many of the warmer parts of Africa, Asia, Oceanica, and other regions. There are about 150 known species, and presumably a large number of forms in South and Central America that are still undescribed.

Seven or more species and forms have been established in the Hawaiian Archipelago since early times and now constitute an important element in the lowland flora. The Hawaiian Islands were discovered by the Spanish in 1555, over two hundred years before the discovery by the great English circumnavigator, Captain Cook. Although historical data concerning these two centuries is very scanty, there is little doubt but that the Spaniards visited the islands repeatedly, and accidentally or purposely introduced various Mexican, Central American, and West Indian plants. The common guava in its several forms was introduced either during this period or within a relatively short time after the discovery by Cook. It was spread rapidly from island to island and locality to locality and has now become a dominant woody weed in many lowland, valley, and foothill regions. It possesses all the attributes essential for aggression- great hardihood with reference to untoward conditions; rapid growth; deep roots; ability to thrive on scanty water supply; power of flourishing on rough, rocky ground; production of sturdy root-sprouts in great numbers; prolific and almost continuous fruit production, with vast numbers of viable seeds; resistance to insect and fungus pests; notable powers of dissemination.

The fruits of all the species are attractive to animals, and the seeds of the wild guavas are widely scattered throughout the islands, both on the lowlands and in the mountains, by means of wild and domestic live-stock and birds. The Chinese dove (*Turtur chinensis*), mynah bird (*Acridotheres tristis*), rice bird (*Carpodacus mexicanus obscurus*), sparrow (*Passer domesticus*), Chinese reed-warbler (*Trochalopterum canorum*), and other introduced birds, as well as the steadily decreasing indigenous birds, all feed freely upon the guavas, and disseminate them to the most remote regions. The wild swine, goats, sheep, and cattle also feed upon the fruits, and assist in the distribution of these ubiquitous plants. Numerous insects, especially of the Orthoptera, gnaw holes in the ripening fruit, and devour the pulpy interior.

As a result of their marked adaptability to local conditions the Hawaiian guavas have become serious pests, particularly on the arable lands. The wild guava, together with Hawaii's other chief woody pest, the lantana (*Lantana Camara* L.), occupy thousands of acres, to the practical exclusion of indigenous vegetation. The main guava zone is in the lowland area, including the valleys, ridges, and foothills, up to an elevation of about 300 meters. Isolated trees are not uncommon above this level, but the great tracts of almost unbroken guava "scrub" lie below it. On the islands of Maui and Hawaii, which rise to 3,000 and 4,200 meters, respectively, the upper limit of the guava scrub is usually about 100 meters, but the general proportions of the zones are about the same as on the lower islands.

Land desired for agricultural purposes, that has become overgrown with guava scrub, is very difficult to clear. The roots are so deep, tough, and interwoven that their removal necessitates arduous hand labor; they cannot be plowed up by ordinary methods. Moreover, the roots are so long-lived, even when cut into fragments, and sprout so freely, that every piece must be removed from the soil if the clearing is to be permanent. In hurried or careless clearing of the land, when many roots are left, they quickly send up vegetative shoots and again take possession of the soil. So laborious is the clearing of guava-land that the usual contract price, in the vicinity of Honolulu, is from fifty to one hundred dollars per acre, varying with the density of the scrub and the stoniness of the land.

On side-hills and valley slopes and other waste land that has no agricultural value, the guava, like its close associate the lantana, is a beneficial plant. It improves the soil, both in physical character and in nutritive content; it checks erosion; and gradually ameliorates otherwise barren and unattractive areas. The guava is a successful and valuable pioneer, although difficult to eradicate when the land is needed for other purposes. The great areas of guava scrub that are distinctive of so many of Hawaii's lowland regions have a commercial value as bee-pasture. The flowers are fragrant and highly nectiferous, and yield an excellent grade of honey. The wild guava has high rank among the honey-plants of Hawaii.

In addition to the wild forms of guava, which are so common throughout the lowlands, there are a number of choicer varieties occurring only in cultivation. These are restricted to the larger estates, tropical gardens, and older plantations, where the less common tropical economic plants receive special consideration. The Hillebrand gardens, the Moanalua estate, the Jaeger gardens, Ainhau, and gardens in the older settlements at Waimea, Lahaina, Kohala, and Hilo, are examples of situations where these less generally known forms are to be found.

The genus *Psidium* is myrtaceous, and nearly related to *Myrtus*, *Eugenia*, and *Punica*. The generic name is from the Greek *psidion*, meaning pomegranate, a fanciful reference to the fruit. Guava is from the native Guiana name, *guayaba*. The genus comprises low-growing trees or shrubs, characterized by leaves which are opposite, petiolate, glabrous, pubescent or tomentose, and pinnately veined. The flowers are solitary or few (one to three, rarely many), on axillary or lateral peduncles; they are usually rather large and whitish. The calyx-tube is urceolate or pyriform, adnate at the base; lobes four or five, persistent; upper free portion entire and sometimes closed over the flower in the bud, and later coming off entire or splitting irregularly into two to five lobes. The petals are four or five, free and spreading. The stamens are numerous, disposed in many series and inserted upon the disk; filaments filiform; anthers oblong or linear, basifixed, and longitudinally dehiscent. The ovary has two to seven, commonly four, locules, with many ovules in each locule, inserted on bifid, axile placentas. The style is slender, the stigma peltate or subcapitate. The fruit is a berry, in shape ovoid, globose or pyriform, and about 2.5–7.5 cm. long and crowned with the calyx-limb. The skin is thin and delicate, yellow to red in color, sometimes green. The seeds are few to numerous, small, hard, kidney- or horseshoe-shaped; the embryo curved, with a long radicle and short cotyledons. The guavas are all readily propagated from seed, and often fruit the second year from seed. The fruit of none of the horticultural forms is suitable for shipping, as it is too delicate, and ripens too quickly.*

The Common Yellow Guava

This species, *P. Guajava* L., in its several forms, is the most abundant representative of the genus in the Hawaiian flora. It is also called lemon guava, or wild guayaba although these names are not distinctive. The Spanish name is *guayaba*, and the aboriginal Mexican name, *xalxocotl*. It ranges from Mexico to Central America and Peru. It is highly variable, and has many horticultural forms, which are not thoroughly known. The two varieties that are commonly given in the literature, "*pomiferum*" and "*pyriferum*," referring to the shape of the fruit, are no longer given botanic status, as they represent indefinite variations. In California a variety is known to the trade as "Hawaiian Guava"—it has a yellow skin and pink flesh—but has not been demonstrated to be a genuine variety.

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* Engler & Prantl (Nat. Pflanzenfam 3^7: 67–69), give the following characterization of the genus:

Psidium L. (*Acca* Berg, *Calyptropsidium* Berg, *Mitranthes* Berg z. T.) Blütenachse meist gestreckt, ± über den Frkn. hinaus verlängert. Kelch verwachsenblättrig, beim Aufblühen mit meist bis zum Staminaldiscus reichenden Längrissen in die einzelnen B. oder unregelmässig zerreissend, sehr selten haubenartig abgesprengt. A. oval bis linear, dorsifix. N. knopfig; meist 4–5 (2–7) Frb., die nicht ganz bis zur Achse verwachsen, so dass die Placenten parietal bleiben und in jeder Kammer einen oblongen Kranz bilden.—Alles übrige wie bei *Myrtus;* nur die (meist behaarten) B. und die Bl., überhaupt die ganzen Pfl., durchschnittlich kräftiger.

Their synopsis of the genus, with typical species, is:

Sect. 1. APERTIFLORA Ndz.
- *A*. OBLONGIFOLIA Ndz.: *P. ciliatum* Benth.; *P. aromaticum* Aubl.
- *B*. OBVERSIFOLIA Berg.: *P. Cattleyanum* Sabine.
- *C*. ALBOTOMENTOSA Berg: *P. incanescens* Mart.; *P. grandifolium* Mart.

Sect. 2. CALYPTRATA Ndz.
- *A*. INTEGRIFOLIA Ndz.: *P. Guayava* Raddi; *P. Araça* Raddi.
- *B*. CRENATIFOLIA Berg: *P. striatulum* DC.; *P. fluviatile* Rich.

Sect. 3. CALYPTROPSIDIUM Berg: *P. eugenioides* (Comb.) Ndz.

The common guava is an arborescent shrub or small tree, sometimes rising to the height of 9–12 m., but usually only 3–6 m. The trunk is slender, and usually divides close to the ground into a number of sinuous stems. The outer bark exfoliates in large brittle flakes or scales, exposing the beautiful smooth, greenish brown inner bark. The mottled trunk of the guava is very attractive and has distinct ornamental value. The young branches are pubescent and four-angled or winged. The leaves are ovate to oblong-elliptic, 8–15 cm. × 5–7 cm.; apex usually acuminate, base rounded; light green, chartaceous, glabrous above, soft pubescent beneath. The principal veins are very prominent, impressed above and raised below. The petiole is short, 5–7 cm. in length.

The flowers occur on the branches of recent growth; they are white, fragrant, and in clusters of one to three on axillary peduncles 1-2.5 cm. long. The pedicels are about 1.5 cm. long, and bear two small, slender bracts at the upper end. The calyx-tube is oblong-ovate, slightly constricted above the ovary. The calyx is closed before anthesis, splitting into two to four irregular segments, whitish and sparsely hairy within. The petals are broadly oval, about 1.5 × 1 cm., thin, delicate, and white. The stamens are erect or spreading, in a broad cluster; filaments 1 cm. long, anthers pale yellow. An abundance of nectar is produced.

The fruit is globose, ovoid or pyriform. It is 7–10 cm. long, and weighs 140–225 g. The rind is somewhat rough, and changes in color from dark green to brownish yellow and finally to clear, deep yellow. The flesh is whitish, yellowish, or dark pink, usually the latter, and comprises two regions - an outer layer, just beneath the rind, which is firm and finely granular; and a more extensive inner mass, of soft, juicy material. The flavor is sweet or somewhat acid; the distinctive feature is the pronounced musky aroma, which is very penetrating. This aroma, which is highly developed in fully mature fruit of good quality, is very agreeable to some people and quite unpleasant to others. The seeds are numerous, reniform or flattened.

The common guava is the chief source of the guava jelly of commerce. Large quantities of guava jelly and jam are manufactured locally, by the orientals, Portuguese, and others. Every little wayside Chinese shop carries a stock of guava jelly. An excellent grade of jelly is made by the American preserving firms for local use and for export to the mainland. However, the manufacture of guava jelly is not as important an industry in Hawaii as it is in many other tropical countries, such as the West Indies, South America, and India. "Goiabada" is made and sold in large quantities in Brazil; it is a thick guava jam. A similar stiff paste is sold in the West Indies and Florida as "guava cheese." Guavas are offered for sale in the various local island markets, and in Honolulu are peddled from door to door by the Portuguese children, who gather the wild fruit. The wide range of guavas in the dietary of white people living in the tropics is well indicated by reference to standard Honolulu cookbooks,* where many recipes are given.

In the Hawaiian Islands the guava is so common as a weed of the roadsides and wastelands that little attention is given to its culture. Dependence is placed upon the abundant supply of wild fruit, rather than upon planted trees. In India, the West Indies, and other countries where this species is not so abundant, the trees are easily raised from seed. The seedlings are transplanted when two or three years old, and bear fruit one or two years after planting. Occasionally a plant will bear fruit the second year from seed, but this is unusual. The prolific production of root-sprouts has been mentioned; this habit affords a very easy method of propagating the plant.

The guava is used in parts of India for dyeing. By boiling the leaves and bark with certain other plants, a black color is obtained, and used for dyeing yarn or cloth. The leaves, either alone or with mango leaves, are used by the poorer classes for tanning. Astringency is a characteristic property of the plant, and the roots, leaves and fruits are utilized medicinally for diarrhoea, scurvy, and similar ailments. The leaves are commonly used in India in the preparation of poultices.

Guava wood is whitish or pale yellowish, moderately hard, even- and close-grained, and weighs about 42 lbs. to the cubic foot. It works easily and smoothly, and takes a beautiful polish. In some countries it is used for tools, spear handles, etc., but has no special uses of this kind in Hawaii. Here it is of much importance as a source of charcoal, and is cut and prepared by the orientals for this purpose. In excursions across country through the guava scrub, one commonly passes the little huts and furnaces of the charcoal burners and finds the men and women themselves, laboriously cutting the saplings, reducing them to proper length, and tending the adobe furnaces.

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* See, for example, Turner, Jessie C., & Alexander, Agnes B. How to use Hawaiian fruits, 30–34. Honolulu. 1910.

The Mediterranean fruit-fly (*Ceratitis capitata*), which before the introduction of its insect parasites[*] seriously infested a great variety of both native and introduced fruits in Hawaii, was exceedingly plentiful in the guavas. It attacked all of the local forms, but was particularly abundant in the strawberry guava and the wai-awi guava. For a number of years, until the introduced parasites became effective in their control work, there were comparatively few uninfested guavas in the region of Honolulu and its adjacent valleys. An estimate, based upon the examination of thousands of fruits in the field during this period, would indicate that eighty per cent. of the guavas at any given time were infested by the fruit-fly. During the past two years, 1915–16, the infestation has not been so serious, owing to a gradual readjustment of the pest to control factors.

The common white mealy bug (*Pseudococcus nipae*), which infests the grape, fig, avocado, annonas, etc., and several species of aphids are very common on the guava foliage. Their favorite habitats are along the prominent veins, on both surfaces of the leaves. They are most abundant on the older leaves, as the very young leaves are quite tomentose. The cottony guava scale (*Pulvinaria psidii*), and the pepper-tree scale (*Aspidiotus lantaniae*) are also plentiful on both wild and cultivated guavas. Fuller's rose beetle (*Aramigus fulleri*) feeds to a great extent on guavas on the islands of Molokai and Hawaii. A bark beetle (*Xyleborus affinis*) is recorded as attacking the wild guavas on Kauai, especially the wai-awi variety.

A number of fungus diseases occur on the guava, but none are apparently of any serious detriment to the plant. The common sooty mold (*Meliola Camelliae* [Catt.] Sacc.) which infests a wide variety of plants in Hawaii—banyan, fig, avocado, citrus fruits, and others—is exceedingly pestiferous on the guava in many districts. It coats the foliage and young branches with an ugly black incrustation and is obviously an inhibiting factor in photosynthesis, transpiration, and respiration.*

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[*] *Galesus silvestrii* Kieffer, *Dirhinus giffardii* Silv., and *Opius humilis* Silv.

The guava fruit-rot is caused by *Glomerella Psidii* (G. Del.) Sheldon, and is more or less common in the West Indies, Florida, and California. This fungus is closely related to the most destructive apple disease in the United States, namely the bitter-rot (*G. rufomaculans* [Berk.] Spaulding & Van Sch.).† The guava fruit-rot first appears as brown decaying spots here and there on the rind. These diseased areas are finally covered with masses of salmon-pink spores. As the fungus continues its activity within the fruit, the latter gradually rots, and becomes wrinkled and shrunken. This disease is not prevalent in Hawaii.

2. THE SWEET RED GUAVA

This is a variety of the common yellow guava and has the general characters of the latter. It requires a more humid habitat and is characteristic of the upper valleys, ravines, and higher levels. The flesh is deep pink, and is firm and sweet. This form may be the classical "*pomiferum*" variety.

3. THE WHITE LEMON GUAVA

This is a cultivated variety of *P. Guajava*, and occurs in a number of the island gardens. The shrub usually grows more erect and arborescent in habit than do the others in this group. The fruit is pyriform (the "*pyriferum*" variety of the literature), and often is three inches in length. The skin is rough and greenish white or yellowish in color. The flesh is white, and quite sweet in flavor, with a delicate aroma. This is a choice fruit for eating out of hand, or for serving sliced on the table.

4. THE WAI-AWI GUAVA

The so-called "white guava" was introduced into the islands at a very early date and is now abundant. It often occurs far up in the mountains and ravines, surrounded by indigenous vegetation, and giving no hint of its exotic origin. It is quite distinct from the common guava, in habit, foliage, and fruit, and undoubtedly deserves specific, or at least subspecific, rank. It is a graceful, symmetrical, tall shrub or tree, with smooth trunk and branches, and a handsome crown of very dark green, glossy foliage. In favorable situations, where the humidity is sufficient, the wai-awi guava attains a height of 6–12 m., although ordinarily it is 3.5 6 m. The leaves are small, oval, smooth and glossy, and are crowded towards the ends of the branches. The sprays of foliage are of distinct beauty. The flowers are white and very fragrant. The wai-awi guava is a prolific producer of fruit, and bears more or less continuously throughout the year. The fruit is small, 2.5 5 cm. long, ovoid, and thin-skinned. It is rich, clear yellow in color, and the flesh is yellow and juicy. This variety does not form continuous scrub stands, but grows here and there, as isolated individuals or in small clumps. The birds feed eagerly upon its fruits and have carried it into nearly all the valleys.

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* See Webber, H. J. Sooty mold of the orange and its treatment. U. S. Dept. Agr. Div. Phys. & Path. Bull. 13: 1–34. *pl. 1–5.* 1897.

† See Halsted, B. D. Laboratory studies of fruit decays. N. J. Agr. Expt. Sta. Rept. 1892, 326–330.

An interesting feature of the guava in Hawaii is that numerous forms of the endemic and highly precinctive arboreal molluscs (*Achati nellidae*), have migrated onto the guavas. Messrs. J. S. and Oliver Emerson, who have made large collections of the Hawaiian snails, report that *Achatinella phaezona*, *A. fulgens* and its *plumata* pattern, *A. cestus* and *A. rutila*, all occur in the wai-awi guava, in such regions as Ke-awa-awa, Niu, and Wailupe Valleys. On the common guava they have found *A. stewartii* (*adusta* pattern), *A. turgida*, and *Auriculella pulchra*, the latter being exceedingly plentiful. The nomenclature is that of Cooke and Pilsbry.

5. The Guisaro Guava

The *guisaro*, *P. molle* Bertol., is also known as the sour *guisaro*, or *guayaba acida*. It is native to Mexico and Central America but has been introduced into Florida and California. It was introduced into the Hawaiian Islands by Mr. A. Jaeger, and specimens occur in Honolulu gardens. The *guisaro* is a low-growing, slender, straggling shrub or small tree. The young branchlets, peduncles, and lower surfaces of the leaves are reddish velvety. The leaves are oval-oblong, 7.5 12 cm. long, apex apiculate, base obtuse or shortly acute; stiff, chartaceous, light green, rough or puberulent. The peduncles are erect and three-flowered. The flowers are white and fragrant. The fruit is abundant; spherical, 2.5 cm. in diameter; the rind is brownish green, becoming pale yellow when mature. The flesh is white, acid, and inferior in quality and aroma. This species is not recommended for planting, as its fruits lack the rich flavor of *P. Guajava*.

6. THE RED STRAWBERRY GUAVA

This species, *P. Cattleianum* Sabine, is also known as the Chinese guava, or purple guava. It is a native of Brazil and is there called *araça de praya*. It is one of the hardiest species. Within relatively recent years it has been introduced into Florida, California, and Hawaii. Like the others, it is a shrub or small tree, 5–8 m. high. The bark is smooth and greenish brown; the branchlets are glabrous. The leaves are obovate-elliptic, 6–9 cm. long, apex acute, base acute to cuneate; thick and leathery, dark green, and glossy. Like the wai-awi guave, it is in flower and fruit almost continuously throughout the year. The peduncles are axillary and one-flowered; the flowers are white and fragrant. The calyx-tube is turbinate, four- to five-lobed; the lobes are broadly oblong; petals obovate, thin; style slender; stigma peltate; ovary four-locular.

The fruit is spherical or ovate, 2.5–3.5 cm. in diameter; rich dark purplish or claret red when mature. The skin is very thin and tender. The flesh is soft, juicy, and melting in texture; it is reddish next to the skin and white toward the center. The flavor is very fine, acid-sweet, and aromatic, and likened to that of the strawberry. It lacks the pungency of *P. Guajava*. There are many small, hard seeds. The sugar content of the guava is not high. The strawberry guava contains more acid than the other varieties but is less acid to the taste.

Although very satisfactory for jellies and jams, the strawberry guava is too fragile for shipment as fresh fruit. The Hawaii Station* carried on some cold storage experiments, which were summarized as follows:

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* Wilcox, E. V., & Hunn, C. J. Cold storage for tropical fruits. Haw. Agr. Exp. Sta. Press Bull. 47. 1914.

> A few fruits of the strawberry guava (*Psidium cattleianum*) were placed in cold storage in the 32° and 36° F. rooms. This fruit is one of the preferred host plants of the fruit fly, and a part of the fruit used in the experiment was infested. The fruit was picked in a nearly ripe condition. The strawberry guava is not well adapted to cold storage. Practically all of the fruit was shriveled and fermented or decayed within one month in both the 32° and 36° F. rooms. Mildew developed abundantly on the rind and only a few of the fruits kept their normal flavor and appearance more than two weeks.

Analyses of various Hawaiian fruits were made by the Hawaii Agricultural Experiment Station in 1914, and the guavas were reported as follows, the numbers representing percentages:

Name	Edible portion	Total solids	Ash	Total sugars	Fat	Fiber
P. Guajava						
Common	84.69	17.78	.531	7.38	.524	4.445
White	87.76	18.75	.676	8.26	.412	5.105
Trinidad	86.62	15.43	.651	6.34	.353	4.425
P. Cattleianum						
Chinese	98.01	20.08	.635	10.01	.418	3.868
Common	98.60	18.27	.743	4.46	.554	6.146
Common	81.16	23.75	.755	5.63	.790	9.378

7. THE YELLOW STRAWBERRY GUAVA

This is *P. Cattleianum* var. *lucidum* Hort., often listed in the trade catalogues as *P. lucidum*, *P. chinense*, and *P. sinense*. It is sometimes called Chinese guava. It is occasionally cultivated in the Hawaiian Islands, but is not common, and does not occur wild. It is a low-growing shrub, with obovate leaves, white flowers, and fruit spherical, 3 3.5 cm. in diameter, and deep sulfur yellow in color. The flesh is sweet, yellow, and more delicately flavored than that of the species.

There are several other species of guava that are of horticultural importance in other parts of the world, but not occurring in the Hawaiian Islands. *P. Friedrichsthalianum* (Berg) Niedenzu, is a well-known Costa Rican species; *P. Araça* Raddi grows on the dry uplands of Brazil; and *P. montanum* Swartz is native to the mountains of Jamaica. The so-called black guava is *Guettarda argentea* Lam., a rubiaceous Jamaican tree, bearing black, globose, fleshy fruits. The "Chilean guava" is a myrtaceous shrub of

Chile (*Myrtus Ugni* Molina), 1–2 m. high, with dark green, shining, ovate leaves, white flowers, and edible, aromatic berries. The "pine-apple guava" of California is *Feijoa Sellowiana* Berg, a South American myrtaceous plant, which resembles the true guavas in growth and fruit.

College of Hawaii,
Honolulu

A new Lejunea from Bermuda and the West Indies[*]

ALEXANDER W. EVANS

(WITH PLATE 24)

The species described below is not uncommon in the West Indies and is perhaps to be expected in Florida and Mexico. It seems to be most abundant at low altitudes, without being strictly coastal in its distribution. The material at first examined, which was scanty and incomplete, was confused with *L. glaucescens* Gottsche, and some of the Bermuda specimens have been listed under this name by the writer.[†] More abundant material has since been available and has shown conclusively that the species is amply distinct.

Lejeunea minutiloba sp. nov.

Pale or dull green, often somewhat brownish with age, scattered or growing in depressed mats: stems about 0.1 mm. in diameter, copiously and irregularly branched, the branches obliquely to widely spreading, often with slightly smaller leaves than the stem but not microphyllous: leaves contiguous to loosely imbricated, the lobe widely spreading, slightly falcate, plane or slightly concave, broadly ovate, when well developed about 0.5 mm. long and 0.45 mm. wide, dorsal margin usually arching partially or wholly across the axis, then strongly outwardly curved to the broad and rounded apex, ventral margin straight or slightly outwardly curved, margin entire or vaguely and minutely crenulate from projecting cells; lobule in the form of a minute triangular basal fold, consisting of only a few cells, the apex represented by a single projecting cell tipped with a hyaline papilla; cells of lobe averaging about 13 μ in diameter at the margin and 25 × 20 μ in the median and basal portions, thin-walled but with minute trigones and occasional intermediate thickenings, cuticle smooth: underleaves distant, orbicular, about 0.2 long, bifid about one half with erect, triangular, acute, obtuse or rounded divisions, rounded at the base, margin as in the leaves: inflorescence autoicous: ♀ inflorescence sometimes borne on a leading branch, sometimes on a more or less abbreviated branch, innovating on one side, the innovation sometimes sterile, sometimes with a second ♀ inflorescence; bracts obliquely spreading, varying greatly in size, distinctly complicate, lobe oblong to obovate, when well developed about 0.45 mm. long and 0.3 mm. wide but often considerably smaller, margin as in the leaves, lobule ligulate, rounded at the apex, about 0.16 mm. long and 0.06 mm. wide; bracteole mostly obovate, about 0.4 mm. long and 0.25 mm. wide, bifid one third or a little more with erect, acute, obtuse, or rounded divisions, margin as in the leaves; perianth obovoid, when well developed about 0.5 mm. long and 0.35 mm. wide, terete in the lower half, distinctly five-keeled above, narrowed toward the base, truncate or slightly retuse at the apex and with a short but distinct beak: ♂ inflorescence usually occupying a short branch and not proliferating, bracts closely imbricated, in two or three pairs, strongly inflated, shortly bifid with a crenulate, strongly arched keel and rounded divisions; bracteole usually single at base of inflorescence, smaller than the underleaves, bifid: capsule about 0.2 mm. in diameter.

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[*] Contribution from the Osborn Botanical Laboratory

[†] Bull. Torrey Club 33: 131. 1906

BERMUDA: on rocks and stones, Church Cave and vicinity, July, 1900, *M. A. Howe 7;* February, 1908, *S. Brown 504, 505;* September, 1912, *E. G. Britton 1088;* on rocks and stones, Walsingham, June, 1900, *M. A. Howe 3;* September, 1905, *E. G. Britton 286;* gully, Tuckerstown, September, 1905, *E. G. Britton 323;* February, 1908, *S. Brown 516;* on bark and roots, Abbott's Cliff, September, 1912 and 1913, *E. G. Britton 888, 931, 932* (in part), *933, 1867;* on bark, without definite locality, 1908, *S. Brown 559a.*

CUBA: in a ravine and on roots of royal palm, San Luis, Oriente, April, 1909, *N. L. Britton 2327, 2329;* on shaded limestone, Tropical Park, Puentes Grandes, Havana, August, 1911, *Brother Leon 2739.*

PORTO RICO: on trunk of a tree, near Rio Piedras, January, 1899, *Mr. & Mrs. A. A. Heller 147;* near Bayamon, July, 1901, *Underwood & Griggs 892;* vicinity of Coamo Springs, March, 1906, *M. A. Howe 1371;* on bark and on earth, Lares to San Sebastian, April, 1913, *Britton & Marble 2799, 2800;* at base of tree, vicinity of Ponce, March, 1913, *Britton & Shafer 1747;* on bark, Candalaria, near Bayamon, February, 1914, *E. G. Britton 1521.*

ST. THOMAS: on banks and stones, St. Peter, February, 1913, *Britton & Marble 1251, 1254, 1255;* on stones, Crown, February, 1913. *Britton & Marble 1365.*

No. 1365 from St. Thomas may be designated the type; a slight admixture of *L. pililoba* Spruce is present.

In the genus *Lejeunea* the lobule when typically developed consists of an inflated sac, ovate in outline, more or less involute along the free margin, and tipped by a single projecting cell with a hyaline papilla at its proximal base. The same general type of lobule is found in several other genera of the Lejeuneae, such as *Rectolejeunea, Ceratolejeunea,* and *Crossotolejeunea.* Unfortunately, in certain species of *Lejeunea,* the lobule often fails to show its typical structure and appears reduced in size or otherwise variously modified. In some cases a prolonged search may be necessary before inflated lobules can be demonstrated at all, and it is not unusual for poorly developed lobules to be associated with plants bearing perianths. In the species here proposed as new no inflated lobules whatever have been seen, although many plants, both with and without perianths, have been examined. The lobule in all cases observed has been in the form of a minute basal fold, consisting of only a few cells. It seems safe to assume, therefore, that lobules of this reduced type represent a constant feature of the species.

With respect to size, the leaves, perichaetial bracts and perianths of *L. minutiloba* exhibit a considerable range of variation, and on slender stems and branches the leaves may be scarcely half as large as on robust stems. The small bracts and perianths are associated especially with short female branches, the size varying approximately with the length of the branch. The smallest bracts and perianths, therefore, are usually to be found on branches which bear a single vegetative leaf in addition to the bracts. The underleaves and bracteoles are much less subject to variation in size than the leaves and bracts; they vary markedly, however, in the character of their apices. These are sometimes acute or even apiculate, sometimes obtuse, and sometimes broadly rounded.

Among related species it will be sufficient to mention *L. floridana* Evans and *L. glaucescens* Gottsche. The first is still known from Florida only, but the second is widely distributed in tropical and subtropical America. Both species are somewhat larger than *L. minutifolia*, the leaves being often 0.7 mm. in length, but they agree with it in inflorescence and in having small orbicular underleaves. In both species, however, the lobules are frequently inflated and conform closely to the usual *Lejeunea* type. *L. floridana* is further distinguished by its much larger perichaetial bracts (often 0.8 mm. in length), by its more shortly bifid underleaves and bracteole, and by the crenulate keels of its perianth, projecting upward as horns. In *L. glaucescens*, the bracts approximate those of *L. minutifolia* in size but the lobules are usually distinctly pointed.

SHEFFIELD SCIENTIFIC SCHOOL,
YALE UNIVERSITY

Explanation of plate 24

LEJEUNEA MINUTILOBA Evans

The figures were drawn by the writer from the type specimen and prepared for publication by Mr. H. D. Rhynedance.

FIG. 1. Part of plant with two perianths, ventral view (male inflorescence not shown), × 45.

FIG. 2. Lobule of a stem leaf, × 250.

FIG. 3. Cells from the apex of a lobe, × 335.

FIG. 4. Cells from the middle of a lobe, × 335.

FIG. 5. Underleaf, × 110.

FIGS. 6–8. Bracts and bracteole from a single involucre, × 55.

FIGS. 9–11. Bracts and bracteole from a second involucre, × 55.

FIGS. 12–14. Bracts and bracteole from a third involucre, × 55.

FIG. 15. Bracteole from a fourth involucre, × 55.

FIG. 16. Lobule of a perichaetial bract, × 250.

FIGS. 17–20. Apices of various bracteole-divisions, × 110.

FIG. 21. Transverse section of a perianth in upper fourth, × 55.

INDEX TO AMERICAN BOTANICAL LITERATURE

1913-1917

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the word America being used in the broadest sense.

Reviews, and papers that relate exclusively to forestry, agriculture, horticulture, manufactured products of vegetable origin, or laboratory methods are not included, and no attempt is made to index the literature of bacteriology. An occasional exception is made in favor of some paper appearing in an American periodical which is devoted wholly to botany. Reprints are not mentioned unless they differ from the original in some important particular. If users of the Index will call the attention of the editor to errors or omissions, their kindness will be appreciated.

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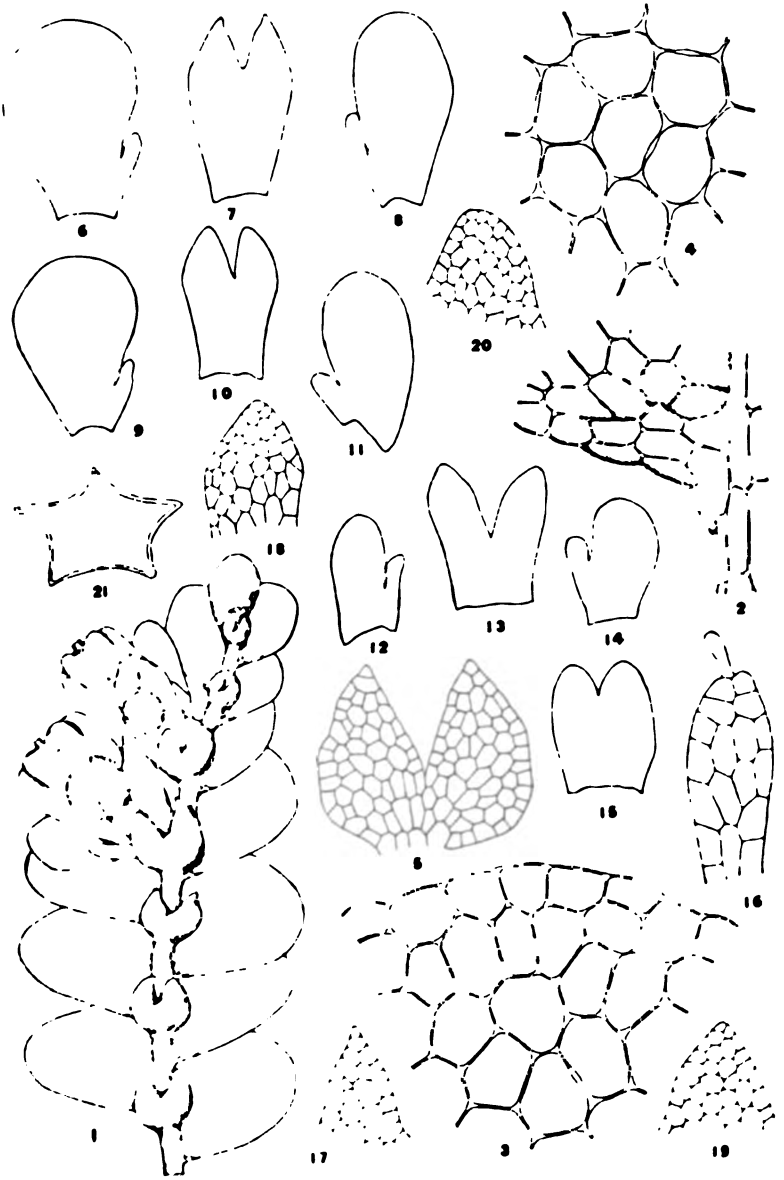

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The development of the embryo-sac and of the embryo in Phaseolus vulgaris

MABEL MARY BROWN

(WITH PLATES 25 and 26)

INTRODUCTION

So far as I have been able to find, the only previously published description of the embryo-sac or embryo of *Phaseolus* is by Guignard (1881), who studied forty species of Leguminosae, among them *Phaseolus multiflorus*. In this species he found that an axial row of but three macrospores is formed. The innermost cell of this row by three successive nuclear divisions forms the embryo-sac, which is typical in every respect; the antipodals are ephemeral. The first division of the egg is transverse, and occurs at the same time that the primary endosperm nucleus divides. A pro-embryo of three cells is formed, the terminal one of which develops into the embryo; the other cells form the suspensor. Divisions follow until an embryo is formed at the apex of a filamentous suspensor, which is two cells in thickness and whose basal cells are conspicuously swollen.

In the present study buds, pistils, and developing fruits were obtained from the following varieties of *Phaseolus vulgaris:* "David Kidney," "Longfellow," "Pole," and "Kidney Wax," plants of which were grown in the greenhouse during the fall and winter of 1914–15 and 1915–16, and "Wardwell's Wax," grown in the

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garden during the summer of 1915. Material was collected from the time the buds began to appear until the fruits were fully grown.

The very young buds were placed in the fixing fluids intact; the floral envelopes were removed from the larger buds and flowers to insure penetration of the fixing fluids. For the same reason the pods were cut into pieces, and in the case of the older pods the young seeds were picked out and placed separately in the fixing solutions. Flemming's solutions, medium and strong; 1 per cent. chrom-acetic acid, Juel's fluid and Carnoy's fluid were used as fixatives. The best preparations showing the development of the macrospores and the embryo-sac were obtained from material fixed in Flemming's medium solution and in chrom-acetic acid. Juel's and Carnoy's fluids gave best results in the fixation of embryos.

Longitudinal sections of these various structures were cut from five to twelve microns in thickness. Flemming's triple stain, Heidenhain's iron-alum haematoxylin, and a combination of the latter with Lichtgrün were used.

I have found no differences between any of the varieties used, so far as the history of the embryo-sac and the embryo are concerned; the description which follows applies equally, therefore, to all the varieties named.

THE MACROSPORES AND THE EMBRYO-SAC

In the varieties of *Phaseolus vulgaris* studied, from two to seven ovules are borne in an apparently single row upon the adherent edges of the carpel. When first formed the ovules are orthotropous, but as growth proceeds they become recurved and are campylotropous when mature.

The two integuments, when fully grown, surround the ovule on all sides, but are slightly shorter on the side toward the placenta. They grow rapidly and by the time that the macrospore mother cell is fully grown the outer integument has reached almost to the apex of the ovule, the inner one being at this time about two thirds the length of the outer integument.

A hypodermal cell in the axial row of the nucellus becomes larger than the surrounding cells and stands out conspicuously among them (PLATE 25, FIG. 1). This cell is typically five-sided in section; it contains a very large nucleus and stains more deeply than the adjacent cells. At a later stage the young macrospore mother cell is separated from the epidermal layer by another layer of cells (FIG. 4). Still later, when the macrospore mother cell is fully grown, there are often two layers of cells between it and the epidermis (FIG. 5); this is not always the case, however, for not infrequently the elongated macrospore mother cell is in the third instead of the fourth layer of cells. No division figures were seen either in the first differentiated hypodermal cell or in the cells of the epidermal layer. For this reason, I have been unable to determine whether the hypodermal cell that is early distinguished by its size itself functions as the macrospore mother cell, or whether, on the other hand, this hypodermal cell divides, one of its daughter cells becoming the macrospore mother cell. On the whole, the arrangement of the subepidermal layers at the later stages (FIG. 5) supports rather more strongly the former hypothesis. Preparations were obtained in which there were what seemed to be two young macrospore mother cells in an axial row (FIG. 3); another preparation showed two young mother cells lying side by side, and in one case two fully grown mother cells lay side by side. In no case, however, was the further development of more than one macrospore mother cell observed.

The fully grown macrospore mother cell is about three times as long as wide (FIG. 6); its nucleus is near the micropylar end of the cell; the chalazal end is usually pointed (FIG. 6), but in some cases quite rounded (FIG. 7). The nucleus remains in the micropylar end of the cell during the prophases of the ensuing division. FIG. 7 shows the nucleus in synapsis. One preparation was obtained showing the heterotypic division; the spindle lies approximately in the center of the cell (FIG. 8). One of the two daughter cells formed by this division fails to undergo a second division, since, so far as my preparations show, a row of but three macrospores is formed (FIG. 9). Guignard (1881) reported the formation of but three macrospores in *Phaseolus multiflorus* but did not determine which of the two daughter cells, formed from the division of the mother cell, fails to divide; he also found a case in which a longitudinal division took place in one of the functionless macrospores;

the innermost macrospore at the chalazal end develops into the embryo-sac, and I find the same thing true in *Phaseolus vulgaris*. In other Leguminosae, according to Guignard, two, three, or four macrospores may be formed and either the innermost spore or the one next it may develop into the embryo-sac. Saxton (1907) finds in *Cassia tomentosa* a deeply buried macrospore mother cell whose division forms a row of four macrospores, of which the one next to the innermost produces the embryo-sac. However, according to Martin (1914), in *Medicago sativa*, *Vicia americana*, and several species of *Trifolium* examined by him, an axial row of four macrospores is formed.

The functional macrospore becomes several times as long as wide before its nucleus divides (PLATE 26, FIG. 11). The two outer macrospores degenerate rapidly, and by the time that the developing macrospore reaches the binucleate stage they have usually disappeared entirely.

After the first nuclear division in the functional macrospore, the two daughter nuclei pass to the respective ends of the sac (FIG. 12), and a large vacuole appears between them. After the second nuclear division each end of the developing macrospore contains a pair of nuclei (FIG. 13). The nuclei at the micropylar end usually remain close together, those at the chalazal end being further apart. After the third division, a group of four nuclei is seen at each end of the embryo-sac.

The polar nuclei begin their migration very soon after the completion of the last nuclear division. Cell division ensues, resulting in the formation of a typical seven-celled embryo-sac (FIG. 14). The egg apparatus presents the usual appearance; the polar nuclei lie a short distance away from the egg apparatus in the median line; at the stage shown in FIG. 14 they have not yet begun to fuse. The antipodal cells are typically triangular in section, and their nuclei are smaller than the other nuclei of the sac. A large vacuole is characteristic of the embryo-sac at this stage, lying between the polar nuclei and the antipodal cells. This development seems to agree, except in minor details, with that of other Leguminosae that have been investigated. Saxton (1907) found an absorptive tissue derived from the antipodal cells in *Cassia tomentosa;* Hofmeister (1858) failed to find antipodal cells in the members of the family studied by him; Hegelmaier (1880), also, did not see the antipodal cells and seems to have confused endosperm cells with the egg apparatus; according to Guignard (1881) the antipodal cells of *Phaseolus multiflorus* are ephemeral; and Strasburger (1880) found that the same is true of the antipodal cells of four species of *Lupinus*.

The egg grows after its formation (PLATE 25, FIG. 10) and becomes long and broad at the base so that it projects into the embryo-sac beyond the synergids (PLATE 26, FIG. 15). The egg nucleus becomes larger and a large vacuole appears in the cytoplasm toward the micropylar end of the egg. The synergids develop a distinct filiform apparatus (FIG. 15) whose striations arise from the neighborhood of a vacuole at the broader end of each synergid. Martin (1914) described a filiform apparatus in *Trifolium pratense*, but with more conspicuous striations than those which I have observed in *Phaseolus vulgaris*. The synergids change from a pear-shaped to a more narrow tapering form. After fertilization the synergids disintegrate and entirely disappear.

The polar nuclei come to lie close together just below the egg (FIG. 14) and remain in this position for some time. Before fertilization, however, they come into close contact with each other and begin to fuse (FIG. 16), but it is quite possible that their fusion may not be completed before the male nuclei enter the sac and one of the latter fuses with the polar nuclei.

In one preparation a pollen tube was seen entering the embryo-sac. It grows through the micropyle and pushes into the embryo-sac between the cells which form a sheath around the micropylar end of the sac.

The nucellus is gradually absorbed during the development of the embryo-sac, and when the latter is mature the nucellar tissue entirely disappears from the micropylar end and from the sides, leaving these parts of the sac in immediate contact with the inner integument; at the chalazal end of the sac, however, the nucellar tissue persists, its cells grow larger and become arranged in quite definite rows which seem to diverge from the point where the integuments arise from the nucellus. This tissue persists until, late in the history of the embryo-sac, it is finally absorbed. According to Hegelmaier (1880), the nucellus in the ovule of *Lupinus* is entirely absorbed after fertilization; Ward (1881) notes the deliquescence of the cells surrounding the embryo-sac of *Lupinus venustus;* and Martin (1914) made similar observations on *Medicago sativa*, *Vicia americana*, and several species of *Lupinus.*

THE EMBRYO

The first division of the fertilized egg is transverse (FIG. 18); the basal one of the two cells so formed typically encloses a large vacuole. The next division occurs in this basal cell and is transverse (FIG. 19), so that a filamentous pro-embryo of three cells is invariably formed (FIG. 20). The third division is a longitudinal one (FIG. 21), in the terminal cell; it is quickly followed by longitudinal divisions in the other two cells of the pro-embryo, which are to give rise to the suspensor (FIG. 22). Divisions may now occur in the longitudinal plane perpendicular to that just described, or the divisions in the second longitudinal plane may be preceded by several transverse divisions. The embryo then consists of four rows of seven or eight cells each (FIG. 23); and the basal cells have begun to show evidences of swelling.

Division now ceases except in the cells at the distal end of the embryo. Anticlinal walls are put in (FIG. 24, *a*) in the cells of the terminal tier. Periclinal walls are next formed, cutting off an outer layer of cells, the dermatogen (FIG. 26). In *Medicago sativa*, *Vicia americana*, and several species of *Trifolium*, Martin (1914) observed that the dermatogen is cut off later than the octant stage; Guignard (1881) also found this true in his work on *Phaseolus multiflorus.* When the embryo is about six or seven cells in length (FIG. 24), the four basal cells of the suspensor become swollen and turgid and much elongated; later the next tier of four cells above them also undergo like changes (FIG. 25). The swollen cells at the base of the suspensor continue to grow in length and retain their inflated appearance until late in the history of the embryo; but when the embryo has grown so as almost to fill the cavity of the sac, its growth seems to cause a compression of the basal cells and they become flattened in the micropylar end of the embryo-sac (FIG. 27). Swollen suspensor cells occur in other members of the Leguminosae; Hegelmaier (1880) reported such cells in the embryo of *Lupinus*, but in this case the cells were multinucleate; Strasburger (1880) observed swollen suspensor cells in *Lupinus*, which in some instances show a tendency to separate from one another. Guignard (1881) also reported the occurrence of inflated cells which are multinucleate in *Orobus aureus*, *O. angustifolius*, and *Pisum sativum*, and suspensor cells which become separated from one another in *Lupinus polyphyllus*. Martin (1914) observed instances in his studies in which the suspensor cells retained their normal appearance and also cases in which the modifications which were noted by other investigators occurred.

At the time of the differentiation of the dermatogen, the embryo proper is almost ovoid in shape (FIG. 26); it retains this form as it increases in size until the appearance of the cotyledons. Cotyledon development begins later than the stage shown in Figure 26; but none of my preparations show satisfactorily the first stages in this development because the plane of the union of the cotyledons is parallel to the flat side of the ovule, and the embryo lies curved in the micropylar end of the embryo-sac. The embryo continues to grow at the expense of the endosperm and of the cushion of nucellar tissue at the chalazal end of the embryo-sac. The nucellus is absorbed, and by the time the embryo is mature the endosperm also has entirely disappeared.

THE ENDOSPERM

The division of the primary endosperm nucleus as a rule precedes that of the fertilized egg (FIG. 17), although one preparation showed the egg nucleus and the primary endosperm nucleus dividing simultaneously. In *Phaseolus multiflorus*, Guignard (1881) found that the division of the egg nucleus and that of the primary endosperm nucleus occur at the same time; Strasburger (1880) observed the simultaneous division of these two nuclei in *Lupinus*; but Martin (1914) found that the first division of the fertilized egg is usually preceded by the first division of the primary endosperm nucleus.

The endosperm nuclei resulting from the first two divisions arrange themselves in the periphery of the embryo-sac. Usually two of them are to be seen near the young embryo, one on either side of it. The later nuclear divisions are not always simultaneous, for in several instances both resting nuclei and nuclei in the various stages of division are to be seen distributed from one end of the sac to the other (FIG. 28); but the order of their arrangement was not identical in the different sacs observed.

The endosperm remains in the form of a peripheral layer in the embryo-sac until its final absorption by the growing embryo; it is typically thicker around the embryo than in other regions of the sac. After the differentiation of the dermatogen, cell division occurs in that part of the endosperm which immediately surrounds the embryo itself. Each nucleus in this part of the endosperm is surrounded by a very definite cell wall; the cells so formed, however, do not form a compact mass but lie isolated in the undivided cytoplasm (FIG. 29). These cells do not persist but are soon absorbed, and all traces of the endosperm have entirely disappeared by the time of the maturity of the seed.

SUMMARY

1. A large hypodermal cell is early differentiated in the ovule; this either functions as the macrospore mother cell or possibly divides once, one of its daughter cells being the macrospore mother cell.

2. The fully grown macrospore mother cell lies in either the third or fourth layer from the micropylar end of the nucellus.

3. An axial row of three macrospores is formed, the innermost of which develops into the embryo-sac.

4. The nucellus is entirely destroyed at the micropylar end and along the sides by the development of the embryo-sac; the nucellar tissue at the base of the sac takes on a peculiar structure and persists for some time, but finally is itself gradually absorbed by the embryo-sac.

5. The polar nuclei begin to approach each other soon after the eight-nucleate stage of the embryo-sac is reached and remain close together for some time just below the egg; then their fusion takes place.

6. The three antipodal cells disappear at about the time of fertilization.

7. The synergids form a conspicuous filiform apparatus.

8. The pro-embryo consists of a filament of three cells; the

two basal cells form the suspensor and the terminal cell develops into the embryo proper.

9. The dermatogen is cut off when the embryo proper consists of about sixteen cells. When the suspensor consists of four rows of about seven or eight cells each, the two tiers of cells at its base become swollen and conspicuously elongated.

10. The primary endosperm nucleus usually divides before the first division of the egg; two of the daughter nuclei resulting from the first two divisions place themselves on either side of the young embryo; and in succeeding divisions the endosperm nuclei place themselves in the peripheral region of the embryo-sac.

11. The divisions of the endosperm nuclei may be simultaneous, or nuclei in all stages of division may be found at the same time, from resting nuclei at one end of the endosperm to late telophases at the opposite end.

12. Endosperm cells are formed in the region immediately about the embryo, but are later absorbed.

I wish to express my sincere appreciation to Dr. C. E. Allen, who suggested this work and under whose supervision it was done.

UNIVERSITY OF WISCONSIN

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Explanation of plates 25 and 26

All drawings were made with an Abbé camera lucida at table level. Leitz oculars and objectives were used: FIGS. 1, 2, 6–10, 14–20, 22, with ocular 4, oil immersion objective 1/16, tube length 222 mm. (× 2,475); FIGS. 4, 5, 11–13, 21, 23, 25, with ocular 4, oil immersion objective 1/16, tube length 170 mm. (× 1,740); FIGS. 24, 26, 28, with ocular 3, oil immersion objective 1/16, tube length 170 mm. (× 1,530); FIG. 3, with ocular 1, oil immersion objective 1/16, tube length 140 mm. (× 966); FIG. 27, with ocular 3, objective 3, tube length 170 mm. (× 170); FIG. 29, with ocular 3, oil immersion objective 1/16, tube length 140 mm. (× 570). The drawings on PLATE 25 have been reduced one half in reproduction; those on PLATE 26, two thirds.

PLATE 25

FIG. 1. Young nucellus showing enlarged hypodermal cell.

FIG. 2. Young macrospore mother cell.

FIG. 3. Nucellus showing two macrospore mother cells in an axial row.

FIG. 4. Nucellus showing the position of the young macrospore mother cell represented on a larger scale in FIG. 2.

FIG. 5. Nucellus showing two layers of cells between the epidermal layer and the macrospore mother cell.

FIG. 6. Fully grown macrospore mother cell.

FIG. 7. Macrospore mother cell with nucleus in synapsis.

FIG. 8. Macrospore mother cell with nucleus in division.

FIG. 9. Row of three macrospores; the two upper ones are degenerating, the third has enlarged and will develop into the embryo-sac.

FIG. 10. Mature egg.

PLATE 26

FIG. 11. Functional macrospore with the two degenerating macrospores lying above it in the nucellus.

FIG. 12. Binucleate embryo-sac.

FIG. 13. A four-nucleate embryo-sac.

FIG. 14. A mature embryo-sac.

FIG. 15. Egg and synergids showing filiform apparatus.

FIG. 16. Polar nuclei fusing.

FIG. 17. An egg and two endosperm nuclei.

FIG. 18. A two-celled pro-embryo.

FIG. 19. The second division in the pro-embryo.

FIG. 20. A three-celled pro-embryo.

FIG. 21. The terminal cell of the pro-embryo has divided longitudinally.

FIG. 22. An embryo consisting of six cells.

FIG. 23. An embryo after further transverse divisions have occurred; the basal cells are enlarging.

FIG. 24. An embryo showing anticlinal walls in the terminal cells.

FIG. 25. Periclinal walls in the embryo proper.

FIG. 26. An older embryo showing suspensor with no distinct demarcation between it and the embryo proper.

FIG. 27. Embryo showing cotyledon, hypocotyl, and epicotyl. The basal cells are compressed against the integument.

FIG. 28. Endosperm nuclei dividing.

FIG. 29. Endosperm cells formed in the region of the embryo.

Hawaiian trees—a criticism

JOSEPH F. ROCK

In the March number of the *Bulletin of the Torrey Botanical Club* for 1917 (**44**: 145–157), there appeared a paper by Vaughan MacCaughey, entitled "An annotated list of the forest trees of the Hawaiian Archipelago." The paper, which the author describes as the first "comprehensive and concise check list" of the Hawaiian forest trees, is by no means exhaustive. The nomenclature has apparently been copied in its entirety from my book on the indigenous trees of the Hawaiian Islands, published in 1913, and certain more recent articles on critical families, in which species from the islands are described, are not considered.

That the author's knowledge of Hawaiian plants is incomplete is evidenced by his remarks under *Pritchardia*, where he states, "there are at least two well-defined species, *P. Gaudichaudii* H. Wendl. and *P. Martii* H. Wendl." These two species are not at all well defined. Their types, in fact, which Dr. Beccari and I have examined in the Webb herbarium at Florence, Italy, consist of immature leaf specimens only, and their published descriptions are extremely meager. Neither of the two species has been collected again in a wild state since its original discovery, and of *P. Gaudichaudii* no cultivated specimens are extant. It was supposed to have been found on a rock islet off the windward coast of Molokai, not far from the leper colony. Nine other species of *Pritchardia*, however, are now known from the Hawaiian Islands. These species are all well defined and are all represented by complete living and herbarium material. An extensive publication by Beccari,* in which full descriptions may be found, seems to be unknown to the author.

Besides the works dealing with *Pritchardia*, there are several other instances of unfamiliarity with the recent literature which might be cited. Heimerl's paper on certain genera of the Nyctaginaceae* is a case in point. In this work the Hawaiian representatives of the family are completely revised, and the genus *Pisonia*, of which MacCaughey lists three species, is no longer recognized as occurring in the Hawaiian Archipelago, one species being made the type of the new genus *Rockia* and the other two being transferred to the genus *Calpidia*. Martelli's publications on the Pandanaceae,† in which species from the Hawaiian Islands are described, Loesener's work on the Aquifoliaceae,‡ in which the synonymy of the Hawaiian species of *Ilex* is revised, and my own paper on the Santalaceae§ are also completely ignored.

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* Contributo alla conoscenza delle Palme. Webbia **4**: 143–240. *f. 1–17.* 1913. See also Rock, J. F., A new species of *Pritchardia*. Bull. Torrey Club **43**: 385–387. *pl. 21 + f. 1.* 1916.

To my mind a check list is of doubtful value unless brought up to date. The copying and publishing of names without proper revision and study is certainly not desirable.

COLLEGE OF HAWAII,
HONOLULU

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* Die Nytaginaceen-Gattungen *Calpidia* und *Rockia*. Oesterr. Bot. Zeitschr. 63: 279–290. 1913.

† Enumerazione delle Pandanaceae. Webbia 3: 307–327. 1910; 4: 1–105. *pl. 1–17*. 1913. Le specie e varietà nuove di "*Pandanus*" menzionate nella enumerazione delle Pandanaceae. Ibid. 4: 399–435. *pl. 18–43*. 1914.

‡ Monografia Aquifoliacearum—I. Nova Acta Acad. Leop.-Carol. 78. 1901.

§ The sandalwoods of Hawaii. A revision of the Hawaiian species of the genus *Santalum*. Hawaii Board Agr. & Forest. Bot. Bull. 3: 1–43. *pl. 1–13*. 1916.

The botanical work of Ezra Michener

C. L. Shear and Neil E. Stevens

The reputation of a botanist depends so largely on publication that important work of collecting and collaboration may be very soon forgotten. This has been too nearly true of the botanical work of Dr. Ezra Michener. Almost all of his long life (1794-1887) was spent in a small village in the southern portion of Chester County, Pennsylvania, "almost entirely isolated," as he says, "from the seats of learning, from scientific libraries, and from personal intercourse with the cultivators of science" (8, p. iii). In addition to the numerous duties of a country physician and of a prominent citizen interested in reform movements he accumulated a valuable herbarium, contributed to Darlington's Flora Cestrica, published a "Manual of Weeds" (7) for popular use, rearranged and mounted the extensive Schweinitz collections of fungi in the Academy of Natural Sciences of Philadelphia, and carried on a correspondence and exchange of specimens with the leading mycologists of his time.

Michener himself seems to have regarded his botanical work as of little importance. In his "Autographical Notes" (8), a volume of two hundred pages, in which he gives the main facts of his life and interests, he speaks of his "innate fondness for plants" and describes his early progress in the study of botany. Later references to botanical work are largely incidental, as when he describes a botanical press which he devised (p. 43), or speaks of rearranging his herbarium of more than a thousand plants during an illness which occurred in 1843 (p. 52), or of collecting plants while on a trip to Virginia in 1846 (p. 59). He refers, however, to assisting Dr. Darlington in the preparation of the Florula Cestrica (p. 43). The above facts are summarized by Harshberger (5) in his "Botanists of Philadelphia." A brief biological note, reprinted from the West Chester Republican, was also published in the Friends' Intelligencer and Journal, July 2, 1887 (9).

A few years ago the writers discovered that Michener mounted the fungi in the Schweinitz herbarium in Philadelphia (11, p. 7), and while continuing their investigations on this important herbarium were able to determine the date of this work (10). In trying to determine this latter point the writers made a thorough search in the region about Dr. Michener's home near Toughkenamon, Pennsylvania, for documents which might throw light on the matter.

CORRESPONDENCE WITH CURTIS AND OTHER BOTANISTS

Dr. Michener's correspondence, which is known to have been voluminous and to have contained letters from some of the most eminent scientists of his time, including Curtis, Ravenel, and Tuckerman (see Harshberger 5, p. 180), appears to have been destroyed. No portion of it could be found either at his former residence, now occupied by his grandson, Ezra J. Webster, or elsewhere. Fortunately, however, Miss Alice Swayne, librarian of the Bayard Taylor Memorial Library, Kennett Square, Pennsylvania, who had previously assisted the writers and was aware of their interest in the Michener correspondence, found a few pages of letter press copies of letters from him in his collection of shells now in the possession of the library. Although there are but twelve sheets of this letter press, numbered consecutively 2 to 13, several of which are somewhat worn, some of the letters from Dr. Michener contain information of great value. That such fragmentary records accidentally preserved must be depended on for information concerning a botanist who died only thirty years ago, argues a neglect in the preservation of accurate historical records which is most unfortunate.

Two letters to Curtis, copies of which were found in the letter press referred to, throw so much light on Michener's purpose and methods in taking up the study of fungi, as well as on his personal relations with Curtis that they are here included nearly in full.

[6]* NEW GARDEN 26th of 11th mo 1855

Dear Friend:

It seems a long time since I have written to thee. Thy note of Sept 11th came duly to hand, requesting to have some of *Botrytis infestans* and would have been promptly responded to if I could have found the thing.—Unfortunately the potato tops were gone before it arrived—and I waited to know whether any could still be found—since which time I have been much from home and mostly occupied with other cases.—An unusually wet season ha[s] produced an abundant growth of our favorite plants—the Fungi—of which a large number hav[e] been collected—but from the tone of thy last note (without date) I feel compelled however reluctantly to decline transmitting them at present.

---

* Figures refer to pages of the letter press.

The inducements which led me into the study of the fungi are a desire to supply a blank in the catalogue of Natural productions of Chester County, which some of us contemplated—and while I could not obtain the means to determine all the species myself—I vainly hoped that my services as a collector of fungi, might entitle me to the assistance which I stood in need of in determining species.—Disappointed in this hope, I have but little inducement to prosecute the study much farther—yet there is a charm attending it which will probably [con]tinue as long as I am able to pursue it.—How is the review of Schweinitz progressing? I have been watching for it in the Journal of the Academy. In a few days I expect to commence arranging Schweinitz Fungi—and it would have been a great pleasure to have [?] had the assistance of your corrections during the examination of his species.—I shall however implicitly follow his numbering and labeling [two words blurred] out in the Synopsis Fungorum.—

Enclosed will be found specimens of a few of my back numbers which were marked as desiderata:—

As heretofore
thy friend

M. A. Curtis— E. Michener

N. B.—Please write whenever convenient.—

Curtis's reply to this letter may be readily guessed at from another letter which Michener wrote several weeks later. This letter, which is without address, shows from the context that it was written to Curtis.

[12] New Garden 28th of 1st mo 1856.

Dear friend,

Thine of the 8th instant was duly received.

It was a kno[w]lidge of thy numerous engagements in the Mycological field—apart from "business" proper, which has frequently led me to feel and to express a fear of trespassing too much upon thy time—and, so far as I can recollect, has prevented me from making any claim upon thy attention farther than it may have been convenient to thee to bestow—nor am I conscious of having manifested that "impatience" of which thee speak.—Be this as it may—thy last preceding note commenced by saying—"You need not trouble yourself by sending me specimens too often." This was language which I thought could hardly be misunderstood, and my consequent course has been taken according to my acceptance of it—In future I will send remittances (as in truth I have always done in strict conformity with the conditions laid down in the note referred to viz.—"You are at liberty to [se]nd as often as you please, only leaving the liberty to answer whe[n] I please."

[The next paragraph, of four lines, is somewhat blurred and is here omitted]

> In working over the first eight books of Schweinitz' Fungi, I have been grieved to find a number of the envelopes either missing or empty in addition to the many which rendered valuless by the ravages of insects.—Perhaps the destruction will not be so great after we get through the Hymenomycetes.—
>
> Ever thine with respect,
>
> E. MICHENER.

Four other letters of which letter press copies are preserved deal with Michener's botanical interests. In two letters to E. Lanning he speaks of exchanging specimens, including fungi, and of having received a parcel of fungi from "our friend H. W. Ravenel." In a letter dated "New Garden, 28 of 11 mo., 1855," to Dr. William Darlington, who had apparently referred to Michener some question of fungus identity, he quotes a considerable portion of Fries description of *Penicillium crustaceum* from Fries Systema Mycologicum (3: p. 407, 408), indicating his familiarity with this standard mycological work. In a letter to Mr. Thomas P. James, dated "New Garden, 4th of 1st mo., 1856," he requests the loan of another lens—"I greatly feel the want of another glass. . . . The powers which [I] have are 20, 30, 50 and 250, one intermediate between the two last, say from 80 to 150 would often assist me wondrously."

In writing to Curtis of the proposed "Catalogue of Natural Productions of Chester County" Michener evidently had reference to the work of the Chester County Cabinet, an organization formed under the leadership of Dr. Darlington, the object of which was "two-fold: first, to form a collection of the natural productions of the County; and second, to gather materials for its prospective history" (8, p. 43). Michener evidently undertook the compilation of a list of fungi (6, introduction; 2, p. iv; and 4, p. 458). To this end he corresponded and exchanged specimens with Ravenel and Curtis, especially the latter, until, as he wrote at the age of eighty-five (4),

> "There have been some 1200 species of fungi collected and preserved in this county, a very large percentage of which have passed under the experienced eyes of Berkeley and Curtis, and carry the impress of their determination, it is impossible for me, at this late period of life, to arrange them properly in a catalogue without more efficient aid than I am able to obtain."

OTHER INTERESTS

Michener naturally included the lichens in his studies and sent numerous specimens to Tuckerman for identification (see 12). That he was a collector of no mean ability is shown by the fact that in his list of lichens of Chester County, published in the third edition of Darlington's Flora Cestrica, 1853, there are included (3, p. 456) "about 20 species never before published in this country, one-half of which are entirely new." These new species are all described by Tuckerman, who named one species *Biatora Micheneri*, in Michener's honor. Tuckerman also named a species in this list in honor of the county, *Verrucaria cestrensis*. Tuckerman presented Michener with a complete set of his "Lichenes Americae Septentrionalis," inscribed

"DNO. E. MICHENER,
AUCTOR
10 AUG. 1852."

These volumes, which bear notes in Michener's hand, are now in the possession of the writers.

Darlington's impression of Michener is frankly stated in the introduction to this edition of the Flora Cestrica, in which he refers to him as "a naturalist from whose acumen, diligence, and indomitable perseverance we may fairly expect as thorough an exploration of every department of our Cryptogamy, as the active duties of his profession and the life-time of an Individual will permit."

Michener's interest in natural science was by no means confined to botany. He was co-author with Dr. William D. Hartman of a work on the shells of Chester County, and prepared a considerable portion of the section on "Zoology" in the history of Chester County compiled by Futhey and Cope (4). In this there are numerous footnotes signed with his initials, indicating close field observations on the habits of birds.

In the manuscript "Catalogue of the Museum presented to Swarthmore" are listed with Michener's usual care four hundred and twenty-six species of mammals, birds, and reptiles, arranged in accordance with the nomenclature of the best authorities of his time. The greater portion of these specimens (8, p. 202) had been mounted by Michener himself. The manuscript has been deposited in the library of the Department of Agriculture.

Michener was also interested in genealogy and contributed a history of his family to the history of Chester County just mentioned. There is in the possession of his grandson, Mr. Ezra J. Webster, of Toughkenamon, Pennsylvania, an elaborate genealogical study of the Michener family, prepared by Dr. Michener.

THE MANUAL OF WEEDS

In 1872 Michener published a volume of about one hundred and fifty pages, entitled "A Manual of Weeds or the Weed Exterminator," designed, as he says in his introduction, to supplement Darlington's (2) Agricultural Botany, and "to place in the hands of the young and intelligent culturist * * * a cheap, and reliable Hand book of Weeds." This book does not seem to have received wide circulation. There is no copy in the Library of Congress or in the Library of the Department of Agriculture. A copy in the Bayard Taylor Library at Kennett Square, Pennsylvania, was, however, loaned to the writers by the librarian, Miss Alice W. Swayne.

The manual lists one hundred weeds systematically arranged, many of them with observations as to habit of growth and suggestions for their control. There is also a glossary of botanic terms.

In the introduction, which fills twenty pages, Michener exhibits considerable grasp of the fundamentals of plant physiology. He refers to the leaves as "the essential organs of digestion, assimilation, and respiration." That he understood many of the principles of plant distribution is evidenced by his warning against the practice of throwing weed seeds into water courses, and to the danger of carrying rhizomes from field to field on agricultural implements. He refers to the blackberry as a bi-per-annual because, as he says, "the root is per-annual and the stem strictly bi-annual." A characteristic remark is that "field fence corners cannot appropriately be used for flower gardens."

Some of his ideas as to the control of weeds must have seemed rather radical fifty years ago. For instance, he urges that the weed question is not a matter merely "of individual, of local, or of agricultural interest. It is more than all this. . . . It is national in all its bearings." Then drawing an analogy from the city boards of health and their quarantine laws, he urges "the establishment of an agricultural board of health in every district, invested with ample powers and resources to maintain a healthy agriculture," and adds: "It may be necessary to provide *inspection of seeds* before they are allowed to be sowed." These suggestions are in part carried out at the present time by our Federal Horticultural Board and by state seed inspection laws. It is possible that we may in time arrive at the condition finally urged by Michener, who suggests that in case a farmer does not properly care for his fields "it may be necessary to remove him temporarily from his premises, and to place them in the hands of an agent until they are fully cleansed from the infection."

PHILADELPHIA ACADEMY OF SCIENCES

Michener was elected a correspondent of the Academy of Natural Sciences, Philadelphia, in 1840, and throughout his life it formed his chief contact with the scientific world. While Michener's name appears but rarely in the records, his services to the Academy were considerable and his interest great.

The writers have already called attention to the fact that the mounted portion of Schweinitz's collection of fungi at the Philadelphia Academy is mounted in exactly the same manner as are the specimens in Dr. Michener's herbarium (11). It is now evident that the method of arrangement was original with Dr. Michener. For in the files of the Academy is the following letter written on the outer surface of a brown paper folder indentical in size and kind of paper with those in the Michener herbarium, and having pinned on the inner side three of the small square sheets of ruled paper like those on which the fungi are pasted in his herbarium (11, *pl. 3, 4*). This sheet was evidently intended as a sample, and Michener thriftily utilized the outside of the sample for his letter.

Erysiphe Hed fil: (Evidently not a part of the letter but of the sample, i. e., it is the label.)

AVONDALE 2[illegible]th of 11th mo 18[illegible]5.

Dear Doctor,

I have inclosed a sheet of my paper with a specimen of labels, such as I use, **for thy examination.** From which thee will vary the size of the sheet, and the size and number of the labels, to each sheet—as thy own judgment may direct.—Common Bookbinders boards are not substantial enough for the portfolios—they should be very firm.—

A stouter paper than this sheet would also be better for the first class (Hymenomycetes) as many of the species are very course and rugged . . .

Should we succeed satisfactorily with the Fungi—perhaps we may then be prepared to arrange the Lichens & Musci in the same way—but will try one at a time.

If the portfolios should not be sent with the other materials please inform me what size the Boards for them will be cut.

Respectfully

E. MICHENER

DR. ZANTZINGER.—

The first package of fungi appears to have been sent to Dr. Michener shortly after this letter was written for early in the following year, 1856, he sent a letter to the Academy concerning the problems connected with their rearrangement. This letter contains so much information regarding the condition of the herbarium at that time as well as the part played by Michener in its rearrangement that it is here printed in full.

NEW GARDEN 16 of 1 mo 1856

Botanical Com. Acad. Nat. Sciences,

I have mounted specimens of all that could be found in the parcel of Fungi sent. Many however were totally destroyed by insects—or had otherwise disappeared.—The envelopes very rarely contain more than two, quite common only one specimen—That I have felt a constant fear of being suspected for the same proclivity which characterize some other would-be naturalists. As a *preventive* I would suggest that you carefully look over the collection before sending it so as fully to appreciate its dilapidated condition.

There are two points upon which I wish the advice of the com.—If the port folios are not yet made I would suggest the propriety of reducing the size of the sheets and labels.—I am not unmindful of a desire to preserve uniformity in the entire Herbarium (and this could still be done in appearance on the shelves) but I think it would be at the cost of convenience and utility.—If it does not come too late I would recommend the size and form of the accompanying specimen—The adoption of it would cost you a trifle of lost labour—and me a good deal more but I think would repay it.—

I also wish your advice upon the arrangement—The original idea was to follow Schweinitz Synopsis so far as specimens were to be found—and then to fill up the blanks so far as I can out of my own collection.—But this does not admit of introducing either his own exotic species—or other more recent discoveries in their proper connection.—We have no very good classification but must follow some one—I prefer Lindley's [revised ?].—The specimen sheet is intended to discriminate between the North American & exotic species of Shw. Herb.—and also those which may be subsequently added—by the colour of the paper a reference on the label to the source whence the specimen was derived. If this should be thought sufficiently to designate the specimens you will perceive that additions can at any time be made [reverse of sheet] without interference with the previous labour.—

Should you approve the plan paper could be selected of such size as would cut without much waste.

Please advise me early of your conclusion in the matter.

Yours respectfully

E. MICHENER

N. B.—I can not return the package until I receive the portfolios to place them in. —What would you want done with the old books, envelopes, etc.?—a few of them contain specimens which ought to be preserved—and it might be worth while to retain Sch. own labels along with the specimens—but this would open a wider field for labour.—

E. M.

Evidently, the committee did not agree with Michener that the size of the sheets should be reduced, for the mounted portion of the Schweinitz herbarium at Philadelphia is on sheets of folio size, whereas those in Michener's own herbarium are quarto. Very fortunately, however, his suggestion that the original packets were worth retaining was accepted, as these are now preserved in the Academy.

Michener worked on this herbarium during the winters of 1855-56 and 1856-57, and in 1857 sent to the Academy a considerable collection of fungi, as indicated by the report of "Donations to Museum" in the Proceedings for that year:

> Seven hundred and ninety-six species fungi (finely mounted specimens). Presented by Rev. M. A. Curtis. Two hundred and one species fungi (finely mounted specimens). Presented by Ezra Michener, who prepared all the specimens.

The files of the Academy of Natural Sciences in Philadelphia contain five letters from Michener regarding the rearrangement of the Schweinitz herbarium and in the interval after that only three brief notes Dr. Nolan, Secretary of the Academy, states that while the files are by no means complete, it is very probable that these are all the communications received from Michener, as he was characteristically a man of few words. Two letters written in 1867 referred to copies of the Proceedings of the Society which he had found missing when the volumes were being sent to the bindery. The remaining note written on a half sheet of letter paper is from its date and nature probably the last communication of Dr Michener to the Philadelphia Academy.

TOUGHKENAMON 6 of 3 mo. 1882

EDW. J. NOLAN, M. D.

Dear Friend

Please find enclosed a postal order ($5) for my subscription for the Proceedings of the Acad. Nat. Sc.—

I have taken them for more than forty years, with interest, but the lapse of 88 years wear and tear, has disqualified me for such reading and studies.

Please close my subscription at the end of the current volume.

And oblige
Thine sincerely
E. MICHENER.

THE MICHENER HERBARIUM

Dr. Michener's zoological collections, as stated in a brief supplementary note published with his autobiography, which were given to Swarthmore College in 1869, were there lost in the fire which occurred a few years later. Very fortunately, however, his herbarium as well as a collection of shells remained in the possession of his children. The preservation of the herbarium seems to have been largely due to the interest of his son, Ellwood Michener, who apparently inherited his father's taste for botanical studies and accumulated an herbarium of flowering plants which the writers have examined.

Some years before his death, Ellwood Michener presented the collections of plants and shells to the Bayard Taylor Memorial Library, of Kennett Square, where they remained until 1917. The trustees of the library, however, realizing that the herbarium would be more accessible to scientific investigators as well as more carefully preserved in the Department of Agriculture, sold the collections of fungi to the mycological collections of the Bureau of Plant Industry.

In addition to portions of many of Schweinitz's specimens, as described in an earlier paper (11, pp. 7–11), the Michener herbarium contains numerous specimens from the collections of fungi described by Berkeley and Curtis (1) as well as fungi identified by Michener himself. With the exactness characteristic of all his work Michener indicated on the labels the source of the specimen and by whom it was identified. This collection of fungi which has now been made available for study will prove of great value to American mycologists. The herbarium also contains an excellent collection of lichens, with many authentic specimens from Tuckerman, who identified most of the material. There are also many phanerogams, a good collection of mosses, many of which are from Europe, and a few hepatics and algae.

Although Michener published very little, his contributions to botany were considerable. Realizing the limitations of his own situation and the impossibility of satisfactorily identifying all the species himself he wisely sent his collections for identification to the leading authorities on the several groups, and devoted his own energies to collecting and preparing his herbarium. He thus secured an authoritative and fairly comprehensive flora of his region, and added to the number of known species and to the known distribution of species already recognized, a type of botanical work greatly needed.

BUREAU OF PLANT INDUSTRY,
WASHINGTON, D. C.

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1915-1917

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Reviews, and papers that relate exclusively to forestry, agriculture, horticulture, manufactured products of vegetable origin, or laboratory methods are not included, and no attempt is made to index the literature of bacteriology. An occasional exception is made in favor of some paper appearing in an American periodical which is devoted wholly to botany. Reprints are not mentioned unless they differ from the original in some important particular. If users of the Index will call the attention of the editor to errors or omissions, their kindness will be appreciated.

This Index is reprinted monthly on cards, and furnished in this form to subscribers at the rate of one cent for each card. Selections of cards are not permitted; each subscriber must take all cards published during the term of his subscription. Correspondence relating to the card issue should be addressed to the Treasurer of the Torrey Botanical Club.

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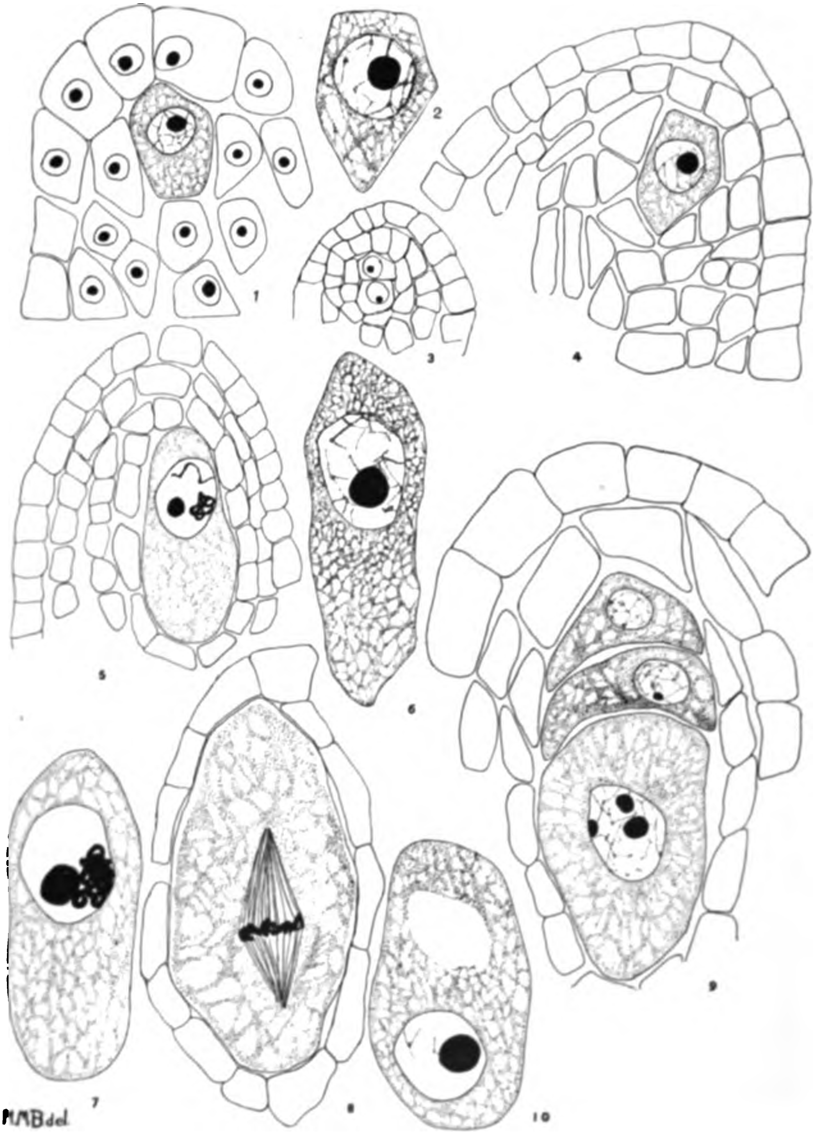

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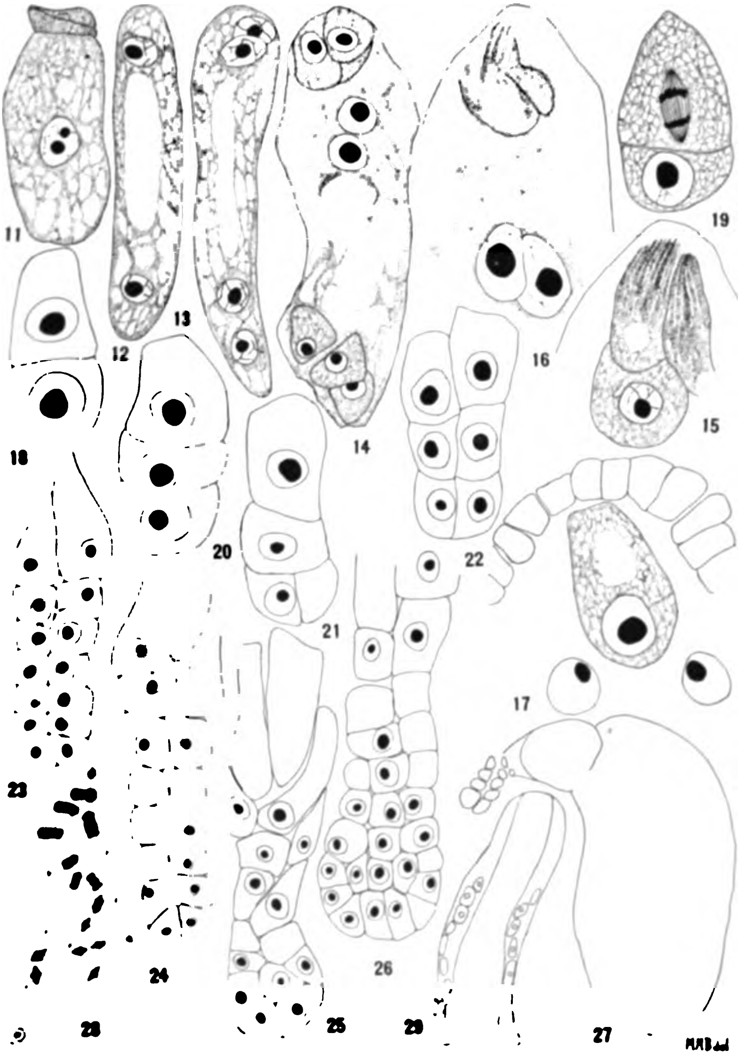

BROWN: EMBRYO SAC AND EMBRYO OF PHASEOLUS

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